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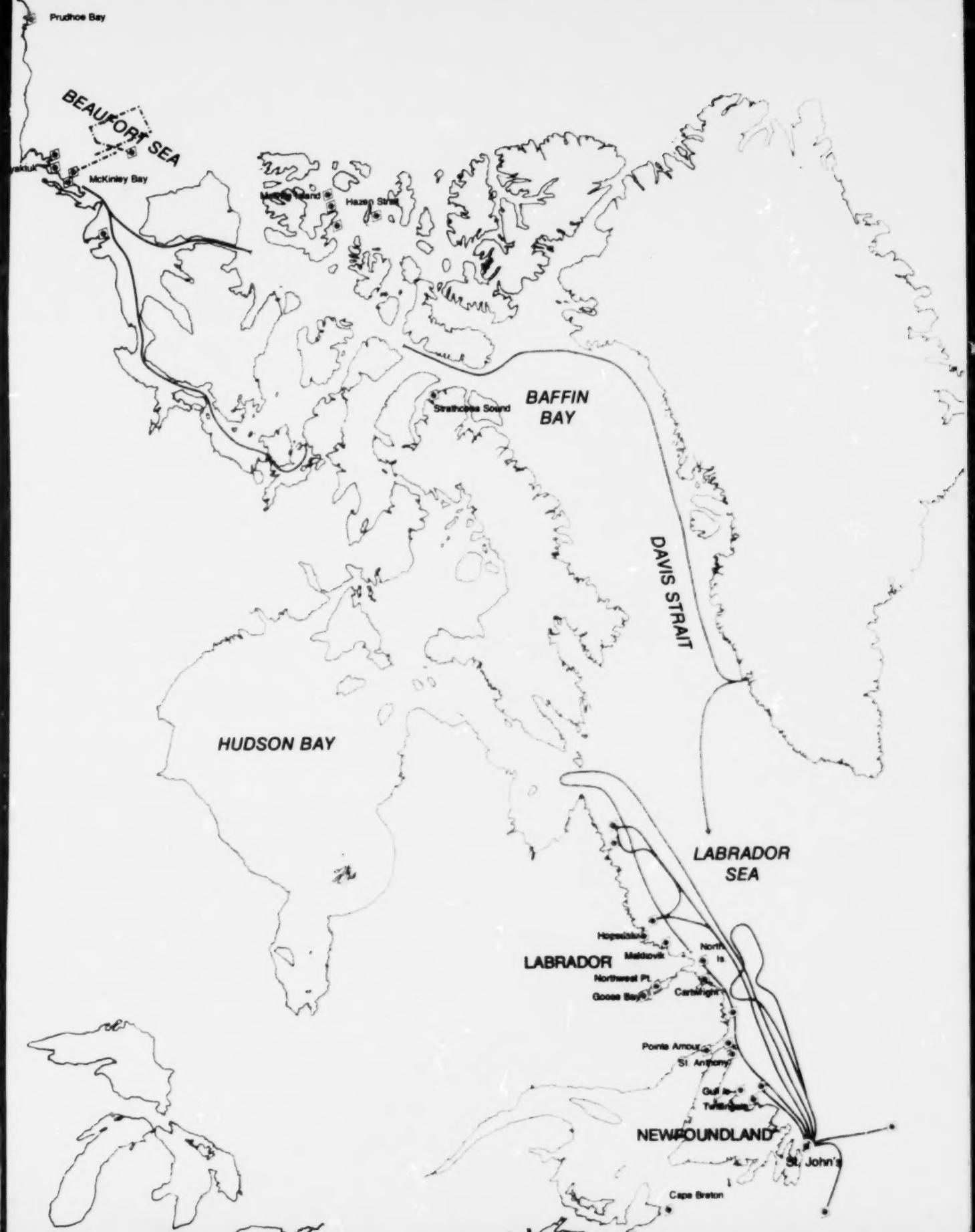
C-CORE

ANNUAL REPORT

1979-80

C-CORE FIELD PROGRAMS 1975 to June 1980

Feb. 1976	**Pointe Amour, Labrador**	Ice Strain measurements — waves travelling through landfast ice
Mar.	**St. Anthony, Newfoundland**	Ice strain measurements — waves travelling through landfast ice
	St. Anthony, Newfoundland	Remote sensing & ground truthing of landfast ice
	Cartwright, Labrador	Remote sensing & ground truthing of landfast ice
May	**Strathcona Sound, N.W.T.**	Ice strain measurements — ice forces against a dock
Aug.	*Lady Johnson*, **Labrador Sea**	Biological study
Nov.	**Pointe Amour, Labrador**	Ice damage to structures & undersea power cables
Jan. 1977	**Melville Island, N.W.T.**	Ice strain measurements — artificial ice island drilling platform
Feb.	**Twillingate, Newfoundland**	Ice strain measurements — waves travelling through ice
	Twillingate, Newfoundland	Surface & airborne impulse radar measurements of landfast ice
	Twillingate, Newfoundland	Remote sensing — synthetic aperture imaging with ground truthing
	Cartwright, Labrador	Remote sensing — synthetic aperture imaging with ground truthing
	Goose Bay, Labrador	Remote sensing — synthetic aperture imaging with ground truthing
	Arctic Explorer, **Labrador Banks**	"Ship in the Ice" — pack ice measurements & biological study
	CCGS Louis St. Laurent, **Eastern Arctic**	"Early Probe" — attempted early voyage into Resolute Bay
Jun.	**Twillingate, Newfoundland**	Impulse radar measurements — draft of icebergs
Aug.	*CSS Hudson*, **Labrador Banks**	Iceberg bottom scouring
Dec.	**Melville Island, N.W.T.**	Ice strain measurements — artificial ice island drilling platform
Feb. 1978	**Twillingate, Newfoundland**	Impulse radar — training program for local industry
	Gadus Atlantica, **Labrador Banks**	Ice strain & remote sensing of waves travelling through pack ice
Mar.	*CCGS Labrador*, **Labrador Banks**	Ice strain & remote sensing of waves travelling through pack ice
Jun.	*CCGS Sir Humphrey Gilbert*, **Labrador Banks**	Impulse radar measurements — draft of icebergs
Aug.	*CSS Hudson*, **Labrador Banks**	Iceberg bottom scouring
Nov.	*CCGS John A. MacDonald*, **Beaufort Sea**	Ice strain measurements — strain in landfast ice
Jan. 1979	**Hazen Strait, N.W.T.**	Ice strain measurements — movements of landfast ice
	Prudhoe Bay, Alaska	Ice strain measurements — artificial ice island drilling platform
Mar.	**Twillingate, Newfoundland**	Ice strain measurements — load bearing capacity of sea ice
	Tuktoyaktuk, N.W.T.	Surface & airborne impulse radar measurements of multi-year ice
	Cape Breton, Nova Scotia	*Kurdistan* oilspill
Apr.	**Gull Island, Newfoundland**	Radar tracking of pack ice and iceberg drift in Notre Dame Bay
	Lake Melville, Labrador	Airborne impulse radar measurements of sea ice
May	*Gadus Atlantica*, **Grand Banks**	Oceanographic study
Jun.	**Point Amour, Labrador**	Radar tracking of shipping & ice movement
Aug.	*CSS Hudson*, **Labrador Banks**	Iceberg bottom scouring
Oct.	*CCGS Franklin*, **Beaufort Sea**	Inaugural patrol
Dec.	**McKinley Bay, N.W.T.**	Study of controlled oilspill under pack ice
Jan. 1980	*Kigoriak*, **Beaufort Sea**	Impulse radar measurements of ice thickness from moving icebreaker
Feb.	*CCGS Franklin*, **Lake Melville**	Winter trip to Northwest Point
	North Island, Labrador	Radar tracking of pack ice and iceberg drift
	St. John's, Newfoundland	Ice strain measurements — load bearing capacity of freshwater ice
Mar.	**Tuktoyaktuk, N.W.T.**	Impulse radar measurements — evaluation of new airborne systems
	McKinley Bay, N.W.T.	Phase II study of controlled oilspill under pack ice
Apr.	*CSS Hudson*, **Grand Banks**	Seabed investigation, Hibernia/Ben Nevis region
May	**Makkovik, Labrador**	Sea ice movement and oil dispersion study
	McKinley Bay, N.W.T.	Phase III study of controlled oilspill under pack ice
Jun.	*Polaris, V*, **Grand Banks**	Seabed investigation, Hibernia/Ben Nevis region


Prudhoe Bay
BEAUFORT SEA
McKinley Bay
Hazen Strait
Strathcona Sound
BAFFIN BAY
DAVIS STRAIT
HUDSON BAY
LABRADOR SEA
LABRADOR
Hopedale
Makkovik
Northwest Pt.
Goose Bay
Cartwright
Ponte Amour
St. Anthony
NEWFOUNDLAND
St. John's
Cape Breton

Research Group

HAROLD SNYDER	Director
DAVID GRENVILLE	Administrator
ALASTAIR ALLAN	Assistant Director (Scientific)
JAMES ROSSITER	Leader, Ice Detection Group
JUDITH WHITTICK	Head, Ocean Engineering Information Centre
WILLIAM WINSOR	Leader, Ice Modelling Group
VAUGHN BARRIE	Iceberg Scour Processes
DAVID BAZELEY	Publications & Seminars
SHERILYN BEATON	Cost Control & Procurement
KENNETH BUTT	Electronics & Equipment Development
DEBORAH DIEMAND	Support Coordinator
BRIAN GAMBERG	Computing Applications & Data Analysis
GARY GIDNEY	Computer Systems
GERALD GOOBIE	Oil - Ice Interactions
JOHN HALL	Instrument Development Engineer
JOHN JOHNSTONE	Instrumentation & Field Technologist
JOHN JONES	Ice Forces & Engineering Systems
THOMAS LAIDLEY	Equipment Development
DAVID REID	Instrument Assembly & Measurement Techniques
ERNEST REIMER	Oil in Ice Countermeasures
TERRY RIDINGS	Sea Ice Research Technician
CHANTAL ROCHE	Multi-Frequency Image Analysis
REBECCA SANTOS	Signal Processing
GORDON SWATERS	Applied Mathematics

Cover Photo: C-CORE's new building under construction at Memorial University of Newfoundland.

C-CORE research team members Glen Gilbert (foreground) and George Power deploy the 'fish' of Bedford Institute of Oceanography's side-scan sonar from the after deck of the *Polaris V*. Using experience gained in investigating iceberg scouring on the Labrador Banks, an extensive field program began in the spring of 1980 to make a detailed survey of the seabed on the Northeastern Grand Banks, in the region of the Hibernia-Ben Nevis wellsites. This project is a joint venture of the Atlantic Geoscience Centre and C-CORE, in co-operation with Mobil Oil Canada, Ltd.

The main laboratory during preparations for the 1979-80 field season. Left to right: Ted Laurentius (trainee), Vaughn Barrie, George Power (trainee), Hany Hamza (doctoral candidate, Faculty of Engineering and Applied Science) and Tom Laidley.

Board of Advisors Report

This Annual Report is an important one to the Board of Advisors since it not only marks the completion of its work, but it heralds the "second phase" for C-CORE.

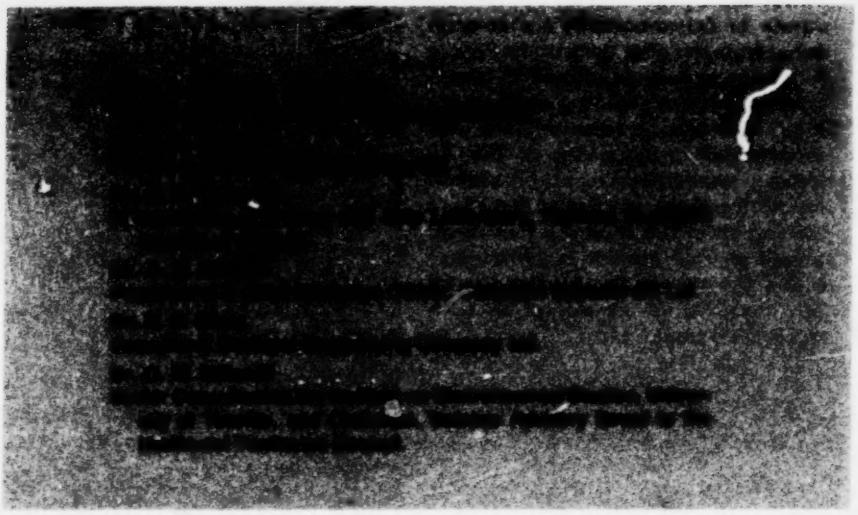
The affairs of C-CORE will be governed under a new Constitution which recognizes C-CORE as an established and important component of Canadian ocean engineering. A single Board of Governors with membership from industry, government and university from across Canada took office April 1, 1980. Members of the Board of Advisors and of the Governing Committee will serve on this new Board during a transitional period of one year; following which up to four appointments will be made annually, for a term of three years, of individuals able to assist and advise C-CORE in matters relating to its finances and administration, its research, the relevance of its work to the concerns of industry and its community relations.

The Board of Advisors held sixteen meetings during the past five years. It is with a high degree of satisfaction that we look back upon our relationship with the Governing Committee and the Director in the process of evolving an aspiration into a viable enterprise. The need for this Centre is clearly evident today as technologies for responsible offshore development are in immediate and increasing demand.

This is an appropriate time, then, to summarize some of the principles upon which this forward looking initiative was founded and some of the steps that led to the Centre's successful launching.

In 1973, the Devonian Group of Charitable Foundations solicited the aid of the Science Council of Canada in identifying projects which needed to be fostered in anticipation of future, unique Canadian needs and opportunities. Among the top priorities was the development of indigenous expertise in working in cold oceans. Dr. Angus Bruneau, then Dean of Engineering, Memorial University of Newfoundland, and a member of the Science Council of Canada, made a proposal to Devonian which allocated funds to stimulate the development of a research organization.

At that point, a number of "ingredients" were identified as critical to the establishment of a strong organization with a meaningful research effort. An initial criterion was the location of the Centre at a University where the full program of research and development from basic



studies through application and demonstration could draw on the facilities and academic versatility of academia and on a skilled and experienced industry in the same community. However, three modifications to traditional university-based research were introduced.

Firstly, it was believed that in order to see transferable results in a short timeframe, researchers should have the opportunity to devote essentially their entire energies to research — free from heavy university teaching and administrative responsibilities. Secondly, it was reasoned that the majority of available resources should be devoted to a single, clearly-defined problem. At the same time, the requirements for large funding and highly qualified researchers was acknowledged in the belief that only this combination could extend the state-of-the-science to a significant degree. This resulted in a firm policy to mobilize funds which were untied by donors but, rather, dedicated to the Centre's approved core research program. Thirdly, working in concert with researchers, operators and regulators in university, industry and government, in Canada and abroad, where much larger funds are spent, was seen as an imperative.

These principles set the direction for the allocation of the catalytic grant with the objective of establishing a self-reliant organization.

C-CORE was established at Memorial University. A Governing Committee and a Board of Advisors were assembled to assist in the Centre's organizational affairs and to advise on research priorities. Mr. Harold Snyder, with an outstanding engineering reputation in the Churchill Falls hydro-electric project, came as C-CORE's Director. His first priority was to recruit the imaginative and vigorous researchers and staff on whom the performance of the Centre would depend.

In guiding C-CORE's initial activities, the Board of Advisors recommended that research be directed to a better understanding of the fundamental engineering properties of sea ice. Although this might appear to have been a rather basic mandate, it became a significant challenge when coupled with a requirement for research into the direct and remote measurement of types, characteristics and dynamics of ice.

In order to avoid repeating the research endeavors of others, emphasis was placed on a requirement that C-CORE collaborate with others. C-CORE devoted a great deal of effort in this role — acting as a participant in joint programs, as coordinator in others and as a catalyst in yet others. In addition to these involvements, the Centre cemented its relationship with industry, government and university by appointing authoritative people, with wide-ranging interests, to the governing and advisory bodies and by the formation of the "Associates of C-CORE". At meetings held in Newfoundland, Quebec, Ontario, Alberta and British Columbia, the Board of Advisors enjoyed the participation of Canadian and international experts in ocean research and marine activities. Elsewhere

in this Report and in the 1978/79 Annual Report will be found the names of those special guests, who have provided the guidance and perspective so important to a new initiative.

In addition to advice and program assistance, financial contributions were also made to the core research program by governments and industry. During this first five-year period the direct financial resources generated for C-CORE through grants, contributions, income from contract research and other sources were as follows:

Devonian Foundation	$3,510,000
Governments	575,000
Industry	965,000
Contracts	925,000
Other	380,000
Total	$6,355,000

C-CORE's expenditures over this period have amounted to $4.5 million. The balance of around $2 million held in the C-CORE Research Trust at March 31, 1980 provides for an essential, though minimum forward research continuity. When the in-kind support of Memorial University, government and industry is included, amounting to some $1.3 million, it can be seen that substantial resources have been mobilized by the activities of C-CORE.

On-going commitments for the future funding of C-CORE's basic research program have been made for periods of up to five years by each of the Associates of C-CORE. This policy of soliciting funds for C-CORE's basic research has, and continues to be, a constraint. We are optimistic that the credibility and accountability which the Centre has now demonstrated will result in its ability to obtain funding from sources which have not been previously accessible.

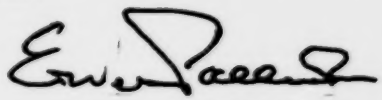
In the Report of the Director and Governing Committee which follows, the research programs and forward plans of the Centre are described. The financial status of the Centre and of the C-CORE Research Trust described in the Auditor's Report indicates the financial stability which C-CORE has attained contemporaneously with its scientific achievements.

This final report of the Board of Advisors presents the opportunity to look back at the founding principles of research organization on which C-CORE was established. During a time when Canadian science policy has been struggling for a means of increasing the nation's research and development effort, C-CORE has shown that the stated policy objectives are achievable. In an important degree, this organization might be viewed as a model of what can be accomplished by cooperation of government, industry and university through the tenacious efforts of visionary and dedicated individuals.

The enabling step in this case was a commitment by a charitable organization. The growth and strength of the Centre resulted from the subsequent bringing together of human, physical and financial resources from multiple sources. It has been widely acknowledged that this synergism is the secret to conducting effective research in Canada. C-CORE has implemented this principle. As time progresses, the flexibility of application of core-funds, together with C-CORE's dynamism in involving others and the goal of providing benefits to others may be found to be the key ingredients which result in successful research in this country. Perhaps this experience will also serve as a model in strengthening other research and development enterprises.

The Board of Advisors leaves office having recommended the elements of a Research Plan for the coming five to ten years. This plan will be reviewed by the newly formed Research Program Advisory Committee of the Board of Governors which will carry on this facet of the work of the Board of Advisors. As a supplementary parting word of advice, the Board strongly recommends that C-CORE continue to develop its liaison function, in serving the needs of the numerous organizations with an interest in cold oceans.

I am joined by the Board of Advisors in expressing our gratitude to the many people who have contributed to C-CORE's success . . . from Pat McTaggart-Cowan who transferred a Science Council study to an initiative; to Angus Bruneau whose vision of St. John's as a centre of ocean excellence motivated us all; to Memorial University President Mose Morgan who provided unfailing support during critical periods; through Premier Peckford, the Hon. Leo Barry and their colleagues and predecessors in the Government of Newfoundland and Labrador whose confidence infected others; to the many officials in both the federal and provincial governments as well as to those people in industry who gave support and understanding; and above all, to Harold Snyder and the staff of C-CORE who unselfishly transformed an idea into an accomplishment.



A. E. Pallister,
Chairman.

Special Guests to Board of Advisors' Meetings

Mr. M. Apostolidis
Senior Vice-President & General Manager
CanOcean Resources Ltd.

Mr. B. C. Gerwick, Jr.
Consulting Construction Engineer

Mr. W. Harland
Vice-President
Crippen Consultants

Mr. L. Humphries
Regional Director
Newfoundland Region
Canadian Coast Guard

Dr. R. Kendall
Chief
Defence Research Establishment (Pacific)

Dr. L. Lewis
Head
Frozen Sea Research Group
Institute of Ocean Sciences
Fisheries & Oceans Canada

Mr. H. Lundrigan
President
Lundrigans Limited

Dr. C. Mann
Director-General
Institute of Ocean Sciences
Fisheries & Oceans Canada

Mr. J. Thompson
Devonian Group of Charitable Foundations

Dr. I. Rusted
Vice-President
Health Sciences
Memorial University of Newfoundland

The Honourable Leo Barry, Minister of Industrial Development, Government of Newfoundland and Labrador, presenting a cheque for $1,000,000 to Memorial University President, M.O. Morgan. This provided the funding for construction of the new building for C-CORE which the Government hopes will become "an international focal point for research and development" in cold ocean engineering. Left to right: Mr. H. Clarke, Deputy Minister of Industrial Development, Dr. F. W. Russell, Chairman, Memorial University of Newfoundland, the Honourable L. J. Barry, Mr. M. O. Morgan and Mr. H. L. Snyder, Director, C-CORE.

Report of The Director & Governing Committee

At the conclusion of the 1979-80 year C-CORE completed five years of operation since its start in the spring of 1975. Then it faced an uncertain future with many ideas untried and goals untested. With the generous and faithful early support of the Devonian Foundation and of Memorial University and the commitment and guidance of the Board of Advisors, the Centre has thrived through the difficult early years and achieved most of its initial objectives.

The Government of Newfoundland and Labrador has demonstrated its support in a most tangible way by funding the construction of a new building to house C-CORE's operations. Located adjacent to its present facilities in the Engineering Building, these facilities should be ready for occupancy in the late fall of 1980.

At year-end, C-CORE had forty employees, including graduate trainees and student assistants, and its annual research budget had been maintained well in excess of the one million dollars minimum set by the Devonian Foundation in its December 1977 agreement with the University. Now, with sustaining support from governments and industry and adequate facilities assured, it looks ahead with confidence, continuing its task of searching for some of the solutions to the problems faced by engineers who are entrusted with developments in Canada's cold ocean environment.

New Constitution

To support, guide and sustain the Centre as it enters its second five years, the governing structure has been simplified by replacing the original Board of Advisors and Governing Committee with a single body, the Board of Governors. The Board will have two functional committees, a Finance Committee and a Research Program Advisory Committee, each with responsibilities clearly set out in the new Constitution which was approved at the end of the year under review, by the Devonian Foundation and the Board of Regents of Memorial University in accordance with the terms of their original agreement.

This constitution reaffirms and clarifies the purposes of C-CORE with the words "to undertake engineering research designed to assist in the safe and orderly development and utilization of Canada's ocean-related resources.

C-CORE shall:

(a) Concentrate its research activities on the solution of a limited number of carefully defined specific engineering problems that are clearly of national interest and of long-term concern to industry and government;
(b) Proceed as far as necessary with its research to demonstrate the viability of the ideas developed and to introduce other organizations to the potential benefits of further development;
(c) Engage in limited contract research when it is in keeping with the purposes set out in (a) above;
(d) Contribute to the training of people competent to work within the ocean environment and capable of solving engineering and related problems identified as critical inhibitors of important potential development and safe operations in that environment;
(e) Carry out its research programs in the public domain and keep people in industry, governments and universities informed by the timely publication of its research results, by the publication of an annual report and by the organization of conferences, seminars and workshops."

A Challenge

In discharging this mandate, C-CORE must continue to select carefully those programs and projects that give promise of major contributions to the resolution of significant engineering problems faced by industry and government in Canada's northern oceans. In carrying out the research programs selected, C-CORE must ensure that people are trained, that Canadian competence is developed in ocean engineering, and that the results of its research are transferred to the user communities so that the technologies developed will be applied in a practical way where they are needed.

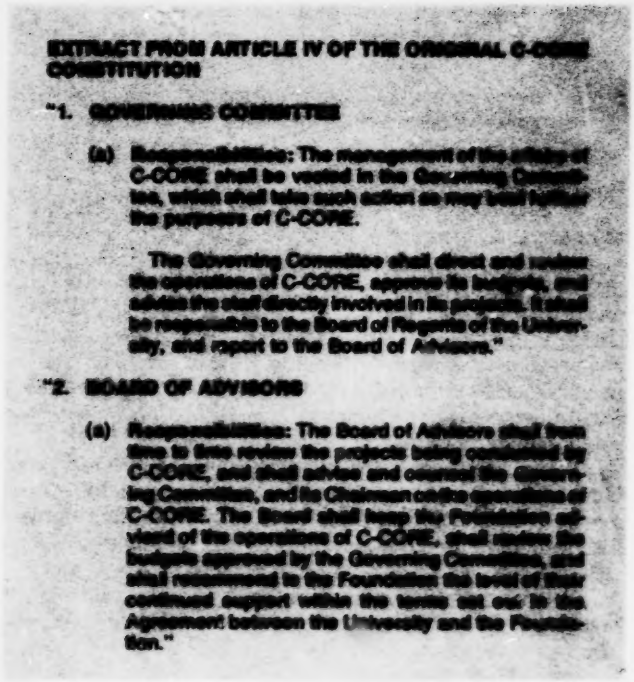
When the Centre's initial research programs were formulated five years ago, few others were working in the field of cold ocean resources engineering. It was relatively straight-forward then to identify certain basic problems that needed to be tackled with little risk of unnecessarily duplicating the work of others.

In the intervening years, great changes have occurred with many companies, consortia and government agencies becoming involved in research that is directly related to, or in support of northern offshore resource development. Now, the Centre's capabilities and limited resources can continue to be matched fruitfully to the most promising opportunities, only if careful ongoing analyses of frontier development plans and research programs are undertaken in close consultation and in co-operation with those involved from industry and government. C-CORE's Research Plan for the next five years, which appears on page 10 of this report, evolved from such consultation and will continue to evolve.

There is ample evidence to suggest at this time that the primary focus of the Centre's activity should continue to be on the ice regimes of our northern oceans. The development of hydrocarbon and mineral production in the north and of safe transportation systems that can be operated economically in Canada's eastern and northern ocean environments will depend on the resolution of many engineering problems. Novel technologies will have to be developed and an array of new support and service systems designed and put in place before northern resource production can proceed on a significant scale. The research programs of the Centre are now focused on the occurrence and behaviour of the ice found in our oceans, and on the operational problems and uncertainties it presents.

The Research Program

During the winter of 1979-80, C-CORE designed and fabricated an improved impulse radar system, optimized for airborne use. This was tested under field conditions in the Beaufort Sea together with a prototype synthetic pulse radar system under development for Transport Canada. Field tests of C-CORE's ice sounding impulse radar system were also carried out aboard the new ice-breaking tug, *Canmar Kigoriak*, as part of an extensive research program undertaken by CANMAR/Dome in the Beaufort Sea (see photo). The objective of this program was to correlate the impulse radar returns from the ice immediately ahead of the bow with data collected from a wide variety of sensors mounted on the vessel. Some success in extracting the ice returns from the total record was achieved following extensive signal processing.



EXTRACT FROM ARTICLE IV OF THE ORIGINAL C-CORE CONSTITUTION

"1. GOVERNING COMMITTEE

(a) Responsibilities: The management of the affairs of C-CORE shall be vested in the Governing Committee, which shall take such action as may best further the purposes of C-CORE.

The Governing Committee shall direct and review the operations of C-CORE, approve its budgets, and advise the staff directly involved in its projects. It shall be responsible to the Board of Regents of the University, and report to the Board of Advisors."

"2. BOARD OF ADVISORS

(a) Responsibilities: The Board of Advisors shall from time to time review the projects being considered by C-CORE, and shall advise and counsel the Governing Committee, and its Chairman on the operations of C-CORE. The Board shall keep the Foundations advised of the operations of C-CORE, shall review the budgets approved by the Governing Committee, and shall recommend to the Foundations the level of their continued support within the terms set out in the Agreement between the University and the Foundation."

The International Workshop on the Remote Estimation of Sea Ice Thickness, organized by C-CORE in St. John's during September, 1979, attracted sixty participants from North America, Europe and the Soviet Union. The Workshop acknowledged that sea ice is a very complex natural material and focussed discussions on the high variability of its electrical properties which are understood so little.

By year-end, C-CORE had begun to wind down its impulse radar program, having concluded that the further development and evolution of this technology and of improved operational systems might be more appropriately undertaken by others. However, building on the radar expertise developed within the Centre, C-CORE researchers started to investigate the possible application of high frequency radars. These may allow the monitoring of sea state and ice conditions well beyond the range of conventional radar.

C-CORE researchers joined the Canadian Coast Guard's new icebreaker *CCGS Franklin* at Tuktoyaktuk in August 1979 for her maiden voyage in the High Arctic.

Further studies of iceberg scour rates were initiated on the Makkovik and Saglek Banks and anaylsis was undertaken of sediment and sedimentary hydrodynamics in areas of scouring. This work was done as part of a joint program with the Atlantic Geoscience Centre at the Bedford Institute of Oceanography. In the course of the *CSS Hudson's* geological reconnaissance cruise of the central and northern Labrador Shelf in the late summer of 1979, a number of icebergs were monitored with the objective of investigating any scour formation. While on Nain Bank, iceberg plotting indicated two large bergs approaching shallow water. The resulting underwater survey of one of them fully documented the scouring of this berg and provided the first recorded case history of an actual iceberg grounding. From this important experience can be developed better understanding of iceberg-seabed interaction.

Following the pilot ice interaction study at Gull Island off the northeast coast of Newfoundland reported last year, a radar tracking installation equipped with a time-lapse camera system was installed at Pointe Amour on the Strait of Belle Isle and operated during the second half of 1979. A similar system to record ice movement in a remote area was subsequently designed and built by C-CORE and installed on North Island, Groswater Bay in the approaches to Lake Melville. The radar system was powered by a thermo-electric generator, fuelled by propane and the special movie camera drive mechanism incorporated in the system was designed by C-CORE and fitted to allow for unattended operation. This project was closely integrated with the program to investigate the feasibility of extending the navigation season into Lake Melville undertaken by the Department of Industrial Development of the Government of Newfoundland and Labrador with the aid of the Canadian Coast Guard.

The Centre initiated a program of field observations of the effect of oil in sea ice following the accident involving the tanker *Kurdistan*. A report, "An Oilspill in Pack Ice", was prepared and submitted to the Environmental Protection Service. C-CORE subsequently participated in an experimental oilspill project undertaken by the Arctic Petroleum Operators Association designed to simulate an oilwell blowout under solid and broken ice cover. Carried out in McKinley Bay, N.W.T. and managed by CANMAR/Dome, the experiment investigated the dynamics of the underwater blowout plume and the oil transport and dispersion processes.

During the past year, C-CORE took the lead in organizing the Oilspill Countermeasures Training Unit (OCTU) to provide practical training in dealing with marine oilspills in cold ocean conditions. Established at the College of Fisheries, Navigation, Marine Engineering and Electronics in St. John's, OCTU works very closely with the Marine Emergencies Division, Newfoundland Region, Canadian Coast Guard and with the oil companies participating in the Eastcoast Spill Response Association.

Technology Transfer

Emphasis continues to be placed on passing on to the engineering profession the results of C-CORE's research work. This takes place through workshops, short courses, symposia, joint ventures, the presence of specially invited guests at Board meetings, and by helping to establish new viable enterprises in the community such as REMOTEC Applications Inc. and OCTU.

A need has been identified for a high technology marine instrument company located in Newfoundland that can make some of the equipment specifically required for ocean and ice engineering and for research. The name, Instrumar Limited has been registered and a company, initially to be wholly owned by the University, is being formed to handle such instrument work. Some of the potential opportunities for the enterprise are:

- development of a creepmeter as an ice safety device;
- building specialized radars;
- development of a radar antenna for reading ice characteristics in arctic seas;
- development of bottom-sampler and photo systems;
- repair and servicing of instruments;
- calibration of ocean instruments related to work in ice;
- rental or sale to users of unique items developed.

Graduate Student Support and Training

The following new initiatives are planned for student fellowships and grants:

1. An increase of the C-CORE Fellowship grants from $8,000 to $12,000 per year in support of students earning a Master of Engineering degree.

2. Payment of half the salary of a graduate student, to a maximum of $12,000 per annum, to encourage practicing engineers to earn a Master of Engineering degree through the Block Program in Ocean Engineering.
3. Making available budget grants of up to $20,000 per research project of which students would receive $12,000 to earn a Master of Engineering degree.

The four graduate trainees who joined the C-CORE Ocean Engineering Training Program in the summer of 1979 will complete their programs in the fall of 1980. They will return to industry with considerable experience gained at sea or in the Arctic on a variety of C-CORE research projects. Their careers will be followed with interest.

Staff

C-CORE continues to attract talented people to its research group and it sees a number of them returning to government and industry to further their careers after making significant contributions to research programs. Field work requires long hours and dedication, sometimes under arduous conditions. The same dedication and effort is shown by the Centre's administrative and support staff. Co-operative programs involving Memorial University facilities and departments continue to increase in number and C-CORE's association with other research groups is expanding.

There is critical need to build on the very small group of people in C-CORE if a real impact is to be made within a reasonable time-scale and the importance of these problems is highlighted by the Hibernia oil discovery off Newfoundland. The pressure of events could lead to setting up or spinning off other groups like C-CORE in order to speed up the essential process of understanding better the complex environment in which development is taking place.

Besides its airborne application, C-CORE's impulse radar could prove to be a useful tool in the evaluation of icebreaker design. As an initial experiment in January 1980, the system was installed in the *CANMAR Kigoriak* during her Beaufort Sea trials. The antenna was mounted on the bow 'looking' at the ice just ahead of the vessel.

A RESEARCH PLAN

C-CORE's research plan for the next five years is the result of ongoing consultation, review and assessment by the Centre's staff with Associates and supporters of the Centre, the international ocean engineering research community and members of the Governing Committee and the Board of Advisors. In the future the Research Program Advisory Committee of the Board of Governors will play an important advisory role in program review and planning.

Analysis of the plans for major resource developments in our ocean frontier regions proposed to be undertaken during the eighties, suggests that requirements for engineering capabilities to operate predictably and safely in our ice frequented oceans will expand rapidly throughout the decade. C-CORE's role within the expanding research community must be carefully chosen. The value of C-CORE's contributions will be dependent on the clarity with which it anticipates needs before they are encountered by the operators, and its ability to arrive at solutions.

The main thrust of the Centre's activity will continue to be focussed on ice, its occurrence and behaviour, and the problems it presents to engineering designers and system operators. The research programs will be organized around the following topics:

Sea Ice

The ultimate goal of this activity is the development of site specific sea ice behaviour models capable of providing an engineer with the detailed information required in the design and construction of facilities and equipment and of providing an operator with the ability to monitor and predict the behaviour of ice hazards.

Sea Ice Detection and Measurement

(a) The development of a compact airborne (fixed-wing) sensor that gives thickness and a measure of strength for many types of sea ice will be a priority. Many aspects of this objective have been achieved in prototype, but there remains a need for future acceptance testing. The goal is a continuous printout of ice thickness much like the conventional depth recorder.

(b) The development of a ship-borne sensor that can measure ice thickness and/or detect anomalies including bergy bits and growlers sufficiently far ahead to enable avoidance action. While our research has been on the application of radar, acoustic techniques need to be investigated.

(c) The development of an over-the-horizon radar to read sea state. The need is for a compact unit that could be mounted on a drillship and receive sea state over a distance of 50 to 100 km. The output would be wave height and period at specific ranges and directions and it is likely that ice conditions could also be determined.

Sea Ice Behaviour

The development of a system for anticipating ridge formation and for defining pressure buildup in ice. Included in this program would be the development of ice behaviour monitoring instruments.

Sea Ice Engineering

(a) The determination of ice force on shore facilities, vessels and bottom founded structures. Particular attention would be given to impact phenomena and the goal would be to produce theoretical force determination formulae derived from full scale field experiments.

(b) The publication of a design handbook that defines sea ice properties in a manner that would be useful to design engineers and that could be related to the various legal codes involved.

Icebergs

The goal of this activity is to develop sufficient understanding of the interaction of icebergs with the sea floor as they ground, or scour, that pipelines and bottom founded structures may be safely designed and economically constructed.

(a) A study of sediment transport and scour infilling that will establish techniques for predicting site-specific scour probabilities and frequencies is being initiated.

(b) Interface forces will be studied so that site-specific designs for pipelines and other bottom founded installations can be established.

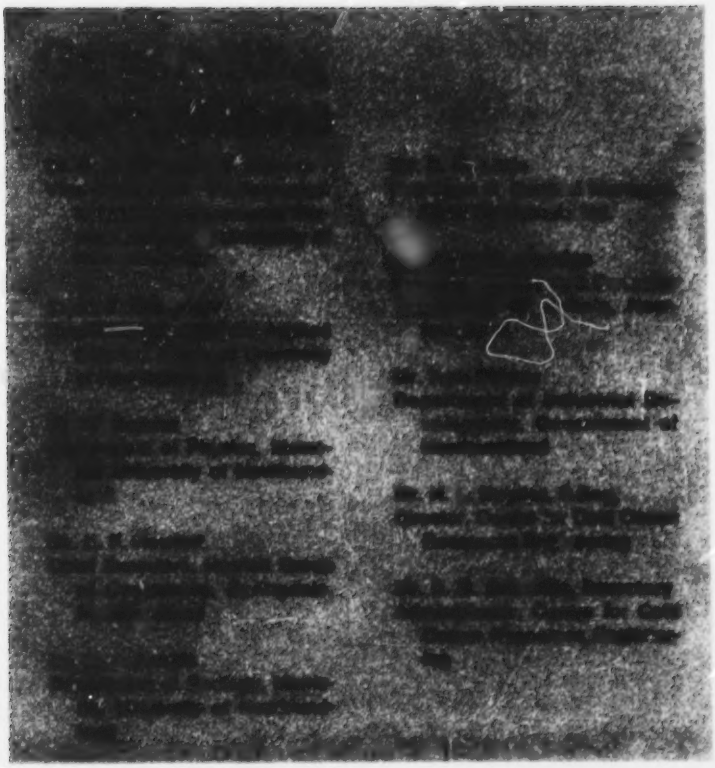
Oil In Ice

Little as yet is understood of the interaction of oil with ice and seawater in our northern oceans, although it is now attracting attention and is the subject of rapidly growing activity and knowledge. The Centre's program will be focussed on the following specific projects:

(a) The development of a reliable locator for oil in and under ice.

(b) The description of the properties and behaviour of different oil types in various ice regimes in order to aid the definition of what is being looked for and a standard specification to be used for the selection of cleanup procedures.

(c) The development of concepts for cleanup systems for the high seas particularly where ice is present.



FINANCIAL

This report contains the audited financial statements for the year ended March 31, 1980 and the Auditor's Report prepared by the Auditor-General of Newfoundland.

C-CORE's operating account position for the year under review is presented in the current report in the accompanying Balance Sheet and Statement of Revenue, Expenditure and Deficit, all of which have been prepared on an accrual basis. A statement showing the position of the C-CORE Research Trust as at March 31, 1980 is included in this report. It shows that the Trust which stood at $280,371 at the beginning of the year under review, received contributions during the year of $2,447,050 and interest was credited to it of $172,919 for the period. The release and transfer to operating account of $930,000 was authorized from the Research Trust in 1979/80 to cover core operating expenditures. A further $390,638 was received from contracts, contributions to programs and other sources and credited to operating account, resulting in total revenue for the year to operating account of $1,320,638. Expenditures for the year were $1,349,968 resulting in an excess of expenditure over revenue for the year of $29,330 and an increase to $138,614 of the deficit carried forward at year-end.

In addition to cash grants, contract revenue and other receipts, C-CORE also received in 1979/80 support-in-kind to an estimated value of $250,000 of which approximately $180,000 represented accommodation, facilities, services and equipment provided by Memorial University.

For the 1980/81 fiscal year, the Centre has budgeted capital and operating expenditures of $1,600,000 and income from all sources of $1,700,000. The Board of Governors has authorized the release of $1,200,000 to cover core operating expenditures during 1980/81.

The 1980 Newfoundland and Labrador budget, brought down on March 28, 1980 by the Honourable John Collins, F.R.C.P. (E), Minister of Finance, contained the following significant passage: " . . . the campus of our University will be enhanced with the construction of a new building to accommodate the Centre for Cold Ocean Resources Engineering (C-CORE) at an approximate cost of $1,000,000. Funding for this project will be provided by Government in 1980-81 through the Department of Industrial Development. It is the firm hope of Government that this new facility will become an international focal point for research and development in this increasingly important discipline."

With this generous renewed declaration of confidence by the Provincial Government, C-CORE was most strongly placed at the end of the year covered by this report to seek the continued funding support required to maintain and expand its activities in 1980/81.

A. A. Bruneau, Chairman

H. L. Snyder, Director

Board of Governors

Dr. A. A. Bruneau, Chairman
Vice-President, Professional Schools and Community Services
Memorial University

Professor C. D. diCenzo**
Dean of Engineering & Applied Science
Memorial University

Dr. W. Denner**
Director, Newfoundland Institute for Cold Ocean Science
Memorial University

Mr. G. R. Harrison**
President, Canadian Marine Drilling Ltd.

Mr. E. F. Hewlett*
Chief Executive, Hewlett Group of Companies

Dr. Noel James*
Department of Geology, Memorial University

Mr. D. G. Little*
President & General Manager, Mobil Oil Canada Ltd.

Mr. S. T. Mathews**
Head, Marine Dynamics & Ship Laboratory
National Research Council of Canada

Mr. P. Outerbridge*
President, A. Harvey & Company Ltd.

Dr. A. E. Pallister*
President, Pallister Resource Management Ltd.

Mr. Ivan Palmer**
Director of Special Projects
Department of Industrial Development
Government of Newfoundland and Labrador

Dr. R. F. Shaw**
Consultant, Montreal Engineering Company Ltd.

Mr. H. L. Snyder, P.Eng.
Director, Centre for Cold Ocean Resources Engineering

Dr. O. M. Solandt*
Senior Consultant to the Institute for Environmental Studies
University of Toronto and Chairman, Science Advisory Board to
the Northwest Territories Council

Dr. Roger Stacey*
Ocean & Aquatic Sciences
Fisheries & Oceans Canada

Mr. D. M. Grenville, Secretary
Administrator, Centre for Cold Ocean Resources Engineering

* Member of the Finance Committee
** Member of the Research Program Advisory Committee

Outerbridge H L Snyder Dr A A Bruneau (Chairman) G R Harrison

Dr R Stacey Dr O M Solandt D M Grenville

Dr I Palmer Dr R T Dempster Mr E F Hewlett Dr R F Shaw Dr A E Pallister

Board of Governors of C-CORE at its first meeting on June 2, 1980. Absent: Dr W Dennler, Dr N James, Mr D G Little Dr S T Mathews. Professor C diCenzo joined the Board in August when he took over from Dr Dempster as Dean of Engineering and Applied Science.

Extracts from C-CORE's new Constitution

ARTICLE V ORGANIZATION

Board of Governors

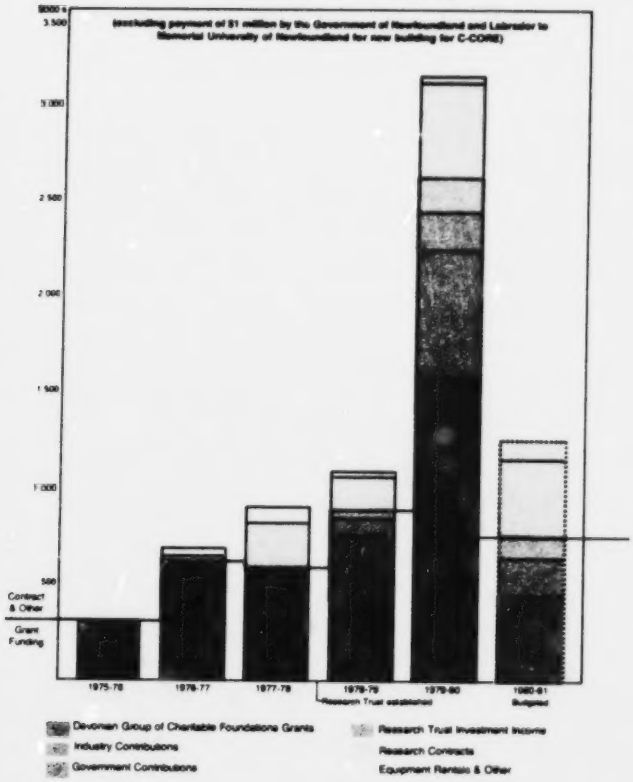
C-CORE is a self-reliant organization of Memorial University which is owner of C-CORE's buildings and equipment and beneficiary of all its assets and liabilities. The Board of Governors is responsible for the funding, research activities, policy direction and management of C-CORE."

ARTICLE VI FINANCIAL ADMINISTRATION

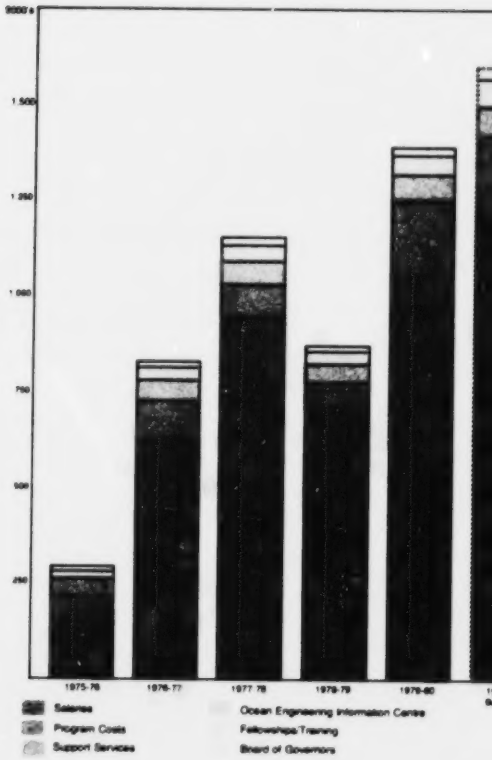
C-CORE Research Trust

All the incoming funds which have been designated as contributions to C-CORE's research programs shall continue to be deposited for credit to the C-CORE Research Trust. The Comptroller of Memorial University administers the C-CORE Research Trust on behalf of the Trustee, the Board of Regents of Memorial University. Following approval of budgets and current operating financial statements, the Board of Governors shall recommend to the Trustee the release of funds from the Trust to the C-CORE capital and operating accounts. The Trustee shall manage and invest Trust Funds to the benefit of the C-CORE Research Trust."

Sources of Funding

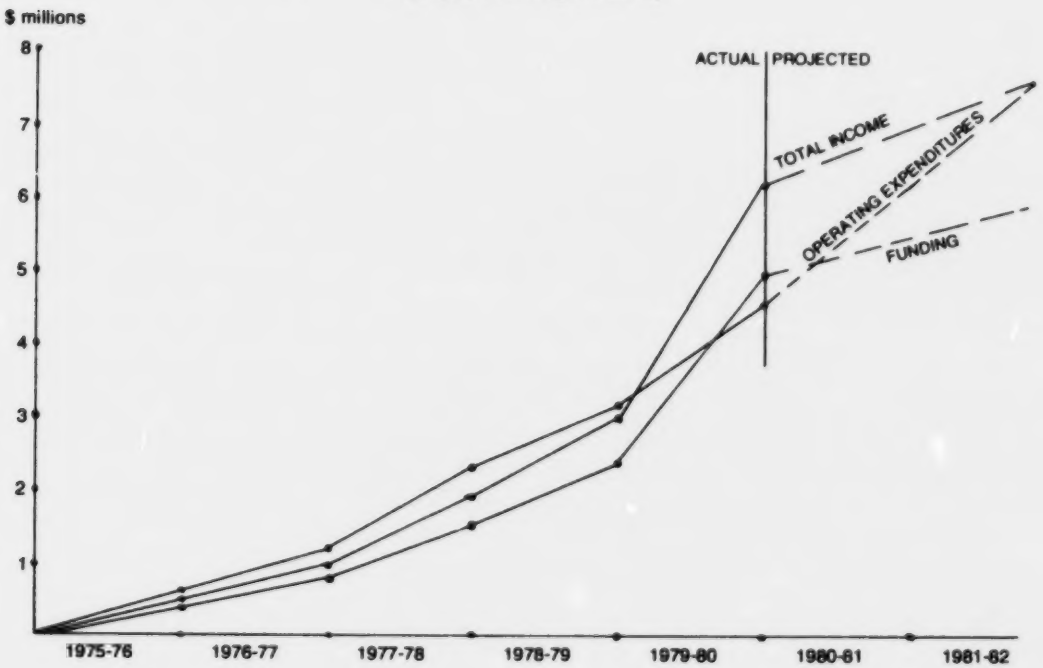


Operating Expenditures



Cumulative Funding and Expenditure

(projected through 1982-83)



NOTE: The above graphs are based on current $'s for each year.

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
BALANCE SHEET
AS AT 31 MARCH 1980

	1980	1979
Assets		
Accounts receivable	$108,232	$245,657
Fixed assets — at cost	227,746	141,066
Less: Accumulated depreciation	111,316	86,081
	116,430	74,985
Total assets	$224,662	$320,642
Liabilities Less Deficit		
Accounts payable and accrued liabilities	$ 41,640	$ 28,572
Interest-free advance from Memorial University of Newfoundland with no specific terms of repayment	321,636	401,354
Total liabilities	363,276	429,926
Deficit	(138,614)	(109,284)
Total liabilities less deficit	$224,662	$320,642

See accompanying notes.

Signed on behalf of the University

Chairman of the Board of Governors

Comptroller of the Memorial University of Newfoundland

STATEMENT 2

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
STATEMENT OF REVENUE, EXPENDITURE AND DEFICIT
FOR THE YEAR ENDED 31 MARCH 1980

	1980	1979
Revenue		
Research Trust	$ 930,000	$ 600,000
Research contracts	369,307	271,723
Other	21,331	18,104
Total revenue	1,320,638	889,827
Expenditure		
Staff salaries	602,506	451,989
Research program	410,906	242,686
Support services	102,406	70,152
Contribution to equipment — new C-CORE Building	100,000	—
Ocean Engineering Information Centre	70,650	66,572
Fellowships	43,991	18,615
Board of Advisors/Governing Committee	19,509	8,888
Total expenditure	1,349,968	858,902
Excess of expenditure over revenue for the year	29,330	(30,925)
Deficit 1 April	(109,284)	(140,209)
Deficit 31 March	$(138,614)	$(109,284)

See accompanying notes.

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
NOTES TO FINANCIAL STATEMENTS
FOR THE YEAR ENDED 31 MARCH 1980

1. **Accounting policies**

(a) Transactions are recorded in the financial statements of the Memorial University of Newfoundland on a cash basis. However, subsidiary records maintained by the Centre's staff have been used to present these financial statements on an accrual basis.

(b) Depreciation is calculated on a straight line basis as follows:

Equipment	5 years
Tools and marine equipment	2 years

2. **Funds in Research Trust**

Cash transactions in the Research Trust were as follows during the year:

Balance at bank 1 April 1979	$ 280,371
Receipts:	
Devonian Foundation	1,577,800
Industry	669,250
Government of Canada	200,000
Investment income	172,919
	2,619,969
Less: Transferred to the Centre's operations	930,000
Net contribution during year	1,689,969
Balance at bank, 31 March 1980	$1,970,340

3. **Support-in-Kind**

Management has estimated the cost of various services provided without charge by Memorial University of Newfoundland and other agencies at $250,000, for the year ended 31 March 1980.

DEPARTMENT OF THE AUDITOR GENERAL
ST. JOHN'S, NEWFOUNDLAND

AUDITOR'S REPORT

The Board of Regents,
Memorial University of Newfoundland,
St. John's, Newfoundland.

I have examined the balance sheet of the Centre for Cold Ocean Resources Engineering as at 31 March 1980 and the statement of revenue, expenditure and deficit for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Centre as at 31 March 1980 and the results of its operations for the year then ended in accordance with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

D. E. Howley, F.C.A.,
Auditor General.

St. John's, Newfoundland
19 June 1980

C-CORE
CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
MEMORIAL UNIVERSITY OF NEWFOUNDLAND
ST. JOHN'S, NEWFOUNDLAND, A1B3X5,CANADA
TELEPHONE (709) 737-8354

Reports and Publications for 1979

79 -1 Wedler, E., and Worsfold, R. D. "A Comparison of Atmospheric Correction Methods Used in Airborne Sea Surface Temperature Mapping". Preprint for ASP-ACSM Convention, Washington, D.C., March 1979.

79 -2 Strong, D. D., Parashar, S. K., and Worsfold, R. D. "Preliminary SAR Data Analysis, Hopedale, Labrador — February-March, 1977". Project SAR '77 Field Data Report #12, 66 pp., January 1979.

79 -3 "C-CORE Annual Report — 1977-1978". 12 pp., February 1979.

79 -4 "Investigation of the Use of Microwave Systems in Detecting and Monitoring Oil Slicks Over Ice and Ice-Infested Waters Phase II & III Report". Contract Report, 63 pp., March 1979.

The work covered in this report was executed by C-CORE for the Canada Centre for Remote Sensing as part of the Arctic Marine Oilspill Program sponsored by the Environmental Emergencies Branch, Environmental Protection Service of Fisheries and Environment Canada. Requests for copies of this report should be directed to: Dr. R. A. O'Neill, Canada Centre for Remote Sensing, 2464 Sheffield Rd., Ottawa, Ontario, K1A 0Y7.

79 -5 Dawe, B., Parashar, S. K., Raney, R. K., Roche, C., and Worsfold, R. D. "Preliminary Radar Analysis Ship-in-the-Ice — February 1977". Project SAR '77 Field Data Report #16, 47 pp., April 1979.

79 -6 "Satellite Ocean-Related Imagery Applications Program Final Report." Contract Report, 487 pp., June 1979.

The work covered by this report was executed by C-CORE under contract to NORDCO Ltd. for the Canada Centre for Remote Sensing, Energy, Mines and Resources Canada. Requests for copies of this report should be directed to: Mr. A. B. Collins, Canada Centre for Remote Sensing, 2464 Sheffield Rd., Ottawa, Ontario, K1A 0Y7.

79- 7 Butt, K.A., Gamberg, J.B., and Rossiter, J.R. "Remote Estimation of the Properties of Sea Ice, Impulse Radar Study of Lake Melville, Labrador". Data Report, 248 p.p., August 1979.

79 -8 Gustajtis, K. A. "Iceberg Population Distribution Study in the Labrador Sea". Data Report, 41 pp. plus 4 maps, July 1979.

79 -9 Rossiter, J. R., and Butt, K. A. "Remote Estimation of the Properties of Sea Ice, Beaufort Sea Field Trip Report — March 1979". Data Report, 36 pp., June 1979.

79-10 Rossiter, J. R., Narod, B. B., and Clarke, G. K. C. "Airborne Radar Sounding of Arctic Icebergs". Proceedings of the Fifth International Conference on Port and Ocean Engineering Under Arctic Conditions, Trondheim, Norway, August 13-17, pp. 289-305.

79-11 Rossiter, J. R. "Review of Impulse Radar Sounding of Sea Ice". Preprint for the International Workshop on the Remote Estimation of Sea Ice Thickness, St. John's, Newfoundland. 16 pp., September 1979.

This report is included in publication 80-5.

79-12 Butt, K.A., and Gamberg, J. B. "Technology of Airborne Impulse Radar". Preprint for the International Workshop on the Remote Estimation of Sea Ice Thickness, St. John's, Newfoundland. 23 pp., September 1979.

This report is included in publication 80-5.

79-13 Gustajtis, K. A. "Iceberg Scouring on the Labrador Shelf, Saglek Bank". Technical Report. 43 pp., November 1979.

79-14 "C-CORE Annual Report — 1978-1979". 12 pp., October 1979.

79-15 "Project SAR '77 Summary Report." Contract Report. 402 pp., November 1979.

The work covered by this report was executed for the Atmospheric Environment Service of Fisheries and Environment Canada, with additional support from the U.S. Naval Office of Research.

Reports and Publications for 1980

80 -1 Reimer, E. "The Visual Identification of Bunker-C Oil in Dynamic Pack Ice." Preprint for the *Kurdistan* Workshop, Dartmouth, N.S. 12 pp., June 1979.

This publication is not available from C-CORE, but is included in publication 80-2.

80 -2 "An Oilspill in Pack Ice". Contract Report, 231 pp., January 1980.

The work covered by this report was executed for the Arctic Marine Oilspill Program of the Environmental Protection Service. Requests for copies should be directed to: Environmental Emergency Branch, Environment Canada, 15th Floor, Pl. Vincent Massey, Ottawa, Ontario, K1A 1C8.

80- 3 Barrie, J.V. "Iceberg - Seabed Interaction (Northern Labrador Sea)". *Annals of Glaciology, Vol. 1, No. 1,* 1980, in press. 20 pp.

80 -4 Laidley, T. E. "An Analysis of the Application of Borehole Logging Techniques to the Study of Sea Ice". Technical Report, 45 pp., April 1980.

80 -5 Rossiter, J. R. and Bazeley, D. P. (eds.) "Proceedings of the International Workshop on the Remote Estimation of Sea Ice Thickness". St. John's, Newfoundland, September 25-26, 1979. Conference Proceedings. 505 pp., May 1980.

80 -6 Rossiter, J. R., Butt, K. A., Gamberg, J. B., and Ridings, T. F. "Airborne Impulse Radar Sounding of Sea Ice". Preprint for the 6th Canadian Symposium on Remote Sensing, May 21-23, Halifax, N.S., 8 pp.

80 -7 Langhorne, P., Rossiter, J. R. and Keliher, T. E. "Remote Estimation of Sea Ice Properties, Ice Core Analysis, Beaufort Sea, March 1979." Data Report, 171 pp., July 1980.

80 -8 Laidley, T. E., Laurentius, T. B., and Hamza, H. "A Load Bearing Capacity Test on a Freshwater Ice Cover." Technical Report, 50 pp., August 1980.

C-CORE CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
MEMORIAL UNIVERSITY OF NEWFOUNDLAND
ST. JOHN'S, NEWFOUNDLAND, ATLANTIC CANADA
TELEPHONE (709) 737-8354

In March 1980, a C-CORE research team returned to the Tuktoyaktuk region of the Beaufort Sea, visited the previous year for developmental testing of C-CORE's impulse radar system. This year's visit was to make an evaluation of the ability of this system to estimate the thickness of a variety of types of sea ice, as compared with that of a synthetic pulse system under development by MPB Technologies Inc. Above, one of the MPB antennas is being made ready for mounting under a Sikhorsky T55H helicopter, by Dr. S. Y. K. Tam and Malcolm Keelty of MPB.

Number/
Numéro
2

SEA SURFACE TEMPERATURES
OBTAINED BY
CAPT. R.A. BARTLETT
OF THE
EXPLORING SCHOONER MORRISSEY
WHILE ON THE BARTLETT-EAST GREENLAND EXPEDITION IN 1936.
[Captain] Robert Bartlett, who took ships to the north coast of Ellesmere Island and sledged to within 150 miles of the North Pole, made twenty two voyages into the Canadian Arctic, and six to other parts of the Arctic, but is almost wholly unknown in Canada. His native province, Newfoundland, did not join the Canadian union until after his death in 1946. Nevertheless, he is now part of Canadian history.
Besides piloting some of the most famous exploring voyages of all time, those of Robert E. Peary and Vilhjalmur Stefansson, Bartlett made four arctic voyages for the American Government and sixteen expeditions of his own which produced, in the period between the world wars, an immense wealth of scientific knowledge. He was the first arctic explorer to place science ahead of exploration.
SCORESBY SOUND
ICELAND
ADAPTED FROM A SECTION OF H.O. CHART No. 318

C-CORE Annual Report 1980-81

The new quarters for the Ocean Engineering Information Centre in the Captain Robert A. Bartlett Building. Seated is Judy Whittick, Head of OEIC; standing is Tom Laidley of C-CORE.

C-CORE's new building is named after Captain Robert A. Bartlett. The Foreword to *Bartlett, the Great Explorer*, by Harold Horwood says:

"Robert Bartlett, who took ships to the north coast of Ellesmere Island and sledged to within 150 miles of the North Pole, made twenty-two voyages into the Canadian Arctic, and six to other parts of the Arctic, but is almost wholly unknown in Canada. His native province, Newfoundland, did not join the Canadian union until after his death in 1946. Nevertheless, he is now part of Canadian history.

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The cover design for this Annual Report is based on a mural which is displayed in the foyer of the Captain Robert A. Bartlett Building. It was designed and created by Terry Ridings. The chart is a reproduction of the 1937 Pilot Chart of the North Atlantic, based on his 1936 scientific voyage along the east coast of Greenland. The chart, and the photographs of Bartlett and his schooner the Effie M. Morrissey, are from the collections of Dr. J. B. Angel and Judge Rupert Bartlett. The pages from Bartlett's original log of the voyage were reproduced and made available by Bowdoin College Library, Maine.

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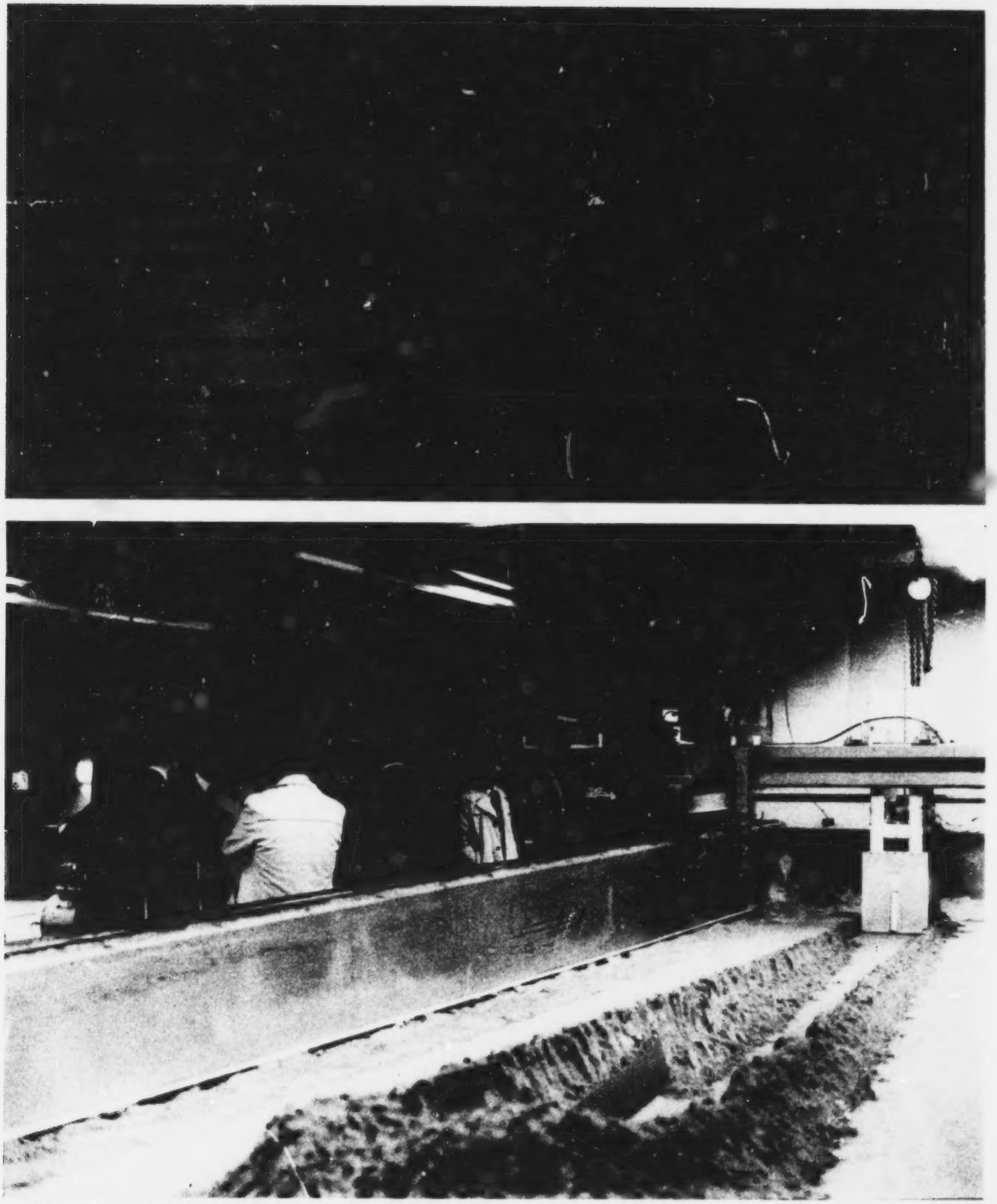
ISSN 0709-7344



C-CORE arranges a workshop each fall, for representatives of its Associates, at which the research plan for the coming year is presented and discussed. Above, the group attending the 1980 workshop view the iceberg scour modelling basin as Dr. R. Chari of the Faculty of Engineering describes the project underway.

The Research Group

Harold Snyder	Director
David Grenville	Administrator
William Winsor	Assistant Director
Vaughn Barrie	Leader, Seabed Group
Ken Butt	Leader, Radar Group
Ernie Reimer	Leader, Hydrocarbon Group
Judy Whittick	Head, Ocean Engineering Information Centre
David Bazeley	Leader, Publications Group
Sherilyn Beaton	Projects Controller
Deborah Diemand	Oil in Ice Countermeasures
Gary Gidney	Computer Systems and Data Processing
Gerald Goobie	Oil in Ice Countermeasures
Phil Jeans	Ice Radar Engineering
John Jones	Ice Forces and Engineering Systems
Ken Klein	Ice Radar Development
Tom Laidley	Remote Sensing of Oilspills
Chris Lynas	Iceberg Scour Analysis
Chris Pereira	Sediment Processes
Ayyakannu Pushpanathan	Engineering Systems
Randy Raymond	Computer Signal Processing
Terry Ridings	Instrumentation
Chantal Roche	OTH HF Radar Data Coordination
Gordon Swaters	Applied Mathematics
Eric Woolgar	Oilspill Dispersion Processes

Extracts from C-CORE's Constitution

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C-CORE is a self-reliant organization of Memorial University which is owner of C-CORE's buildings and equipment and beneficiary of all its assets and liabilities. The Board of Governors is responsible for the funding, research activities, policy direction and management of C-CORE."

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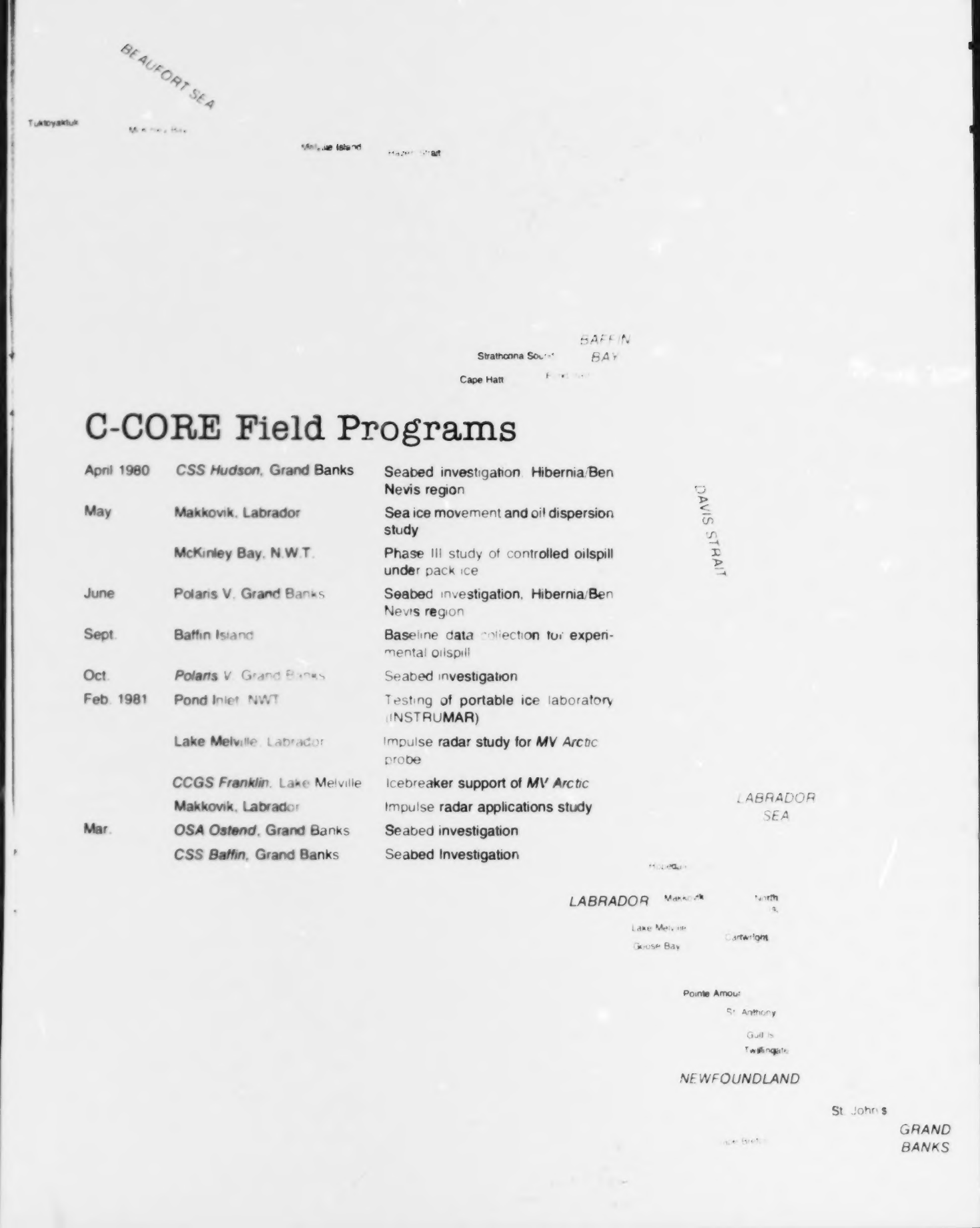


C-CORE Field Programs

April 1980	*CSS Hudson*, Grand Banks	Seabed investigation. Hibernia/Ben Nevis region
May	Makkovik, Labrador	Sea ice movement and oil dispersion study
	McKinley Bay, N.W.T.	Phase III study of controlled oilspill under pack ice
June	Polaris V. Grand Banks	Seabed investigation. Hibernia/Ben Nevis region
Sept.	Baffin Island	Baseline data collection for experimental oilspill
Oct.	*Polaris* V. Grand Banks	Seabed investigation
Feb. 1981	Pond Inlet, NWT	Testing of portable ice laboratory (INSTRUMAR)
	Lake Melville, Labrador	Impulse radar study for *MV Arctic* probe
	CCGS Franklin, Lake Melville	Icebreaker support of *MV Arctic*
	Makkovik, Labrador	Impulse radar applications study
Mar.	*OSA Ostend*, Grand Banks	Seabed investigation
	CSS Baffin, Grand Banks	Seabed Investigation

Board of Governors

Dr. A. A. Bruneau, Chairman
President, Bruneau Resources Management Limited

Professor C. D. diCenzo**
Dean of Engineering & Applied Science
Memorial University

Mr. H. M. Clarke*
Deputy Minister
Department of Development
Government of Newfoundland and Labrador

Dr. W. Denner**
Director, Newfoundland Institute for Cold Ocean Science
Memorial University

Mr. G. N. Ewing*
Assistant Deputy Minister
Ocean Science and Surveys
Fisheries & Oceans Canada

Mr. G. R. Harrison**
President, Canadian Marine Drilling Ltd.

Mr. E. F. Hewlett*
Chief Executive,
Hewlett Group of Companies

Mr. D. G. Little*
President & General Manager,
Mobil Oil Canada Ltd.

Mr. H. Lundrigan*
Senior Vice-President
Lundrigan's Limited

Mr. S. T. Matthews**
Head, Marine Dynamics & Ship Laboratory
National Research Council of Canada

Dr. R. F. Shaw**
Consultant,
Montreal Engineering Company Ltd.

Mr. H. L. Snyder, P. Eng.
Director,
Centre for Cold Ocean Resources Engineering

Mr. D. M. Grenville, Secretary
Administrator,
Centre for Cold Ocean Resources Engineering

* Member of the Finance Committee
** Member of the Research Program Advisory Committee

The Board of Governors in April, 1981. Standing, left to right: Mr. P. N. Outerbridge, Dr. W. W. Denner, Dr. R. Stacey, Dr. R. F. Shaw, Mr. D. M. Grenville, Mr. S. T. Matthews, Mr. H. L. Snyder. Seated, left toright: Mr. E. F. Hewlett, Mr. I. Palmer, Dr. A. E. Pallister, Dr. A. A. Brunneau. Missing from photo are: Dean C. D. diCenzo, Mr. G. R. Harrison, Mr. D. G. Little, and Mr. H. Lundrigan.

oort of the Director and Board of Governors

s the sixth Annual Report of the Centre for Cold sources Engineering covering the period from April March 31, 1981.

ost significant event during the year for the Centre g over and moving into its new building on Memo- pus, adjacent to the Engineering and Geology here C-CORE spent its first five years. The building, funded at a cost of $1 million by the Government of dland and Labrador, was completed on schedule and dget. Occupied at the end of November, 1980 the as formally handed over to the University by the eil Windsor P. Eng., Minister of Development, at a on April 8, 1981. The Hon. Dr. John Collins, Minister e and the Hon. Leo Barry, Minister of Mines and oth of whom had made key contributions to this so participated in the ceremony.

RE's new building was named after Captain Robert , the famous Newfoundland ice captain and pioneer d of cold ocean science. Lord Shackleton, the well ctic explorer, statesman and industrialist, who had rtlett, opened the building and, that evening, gave a ure entitled "Politicians, Polar Bears, and Policy for which was also televised live on the University's nnel in St. John's. The steady and varied stream of the Bartlett Building since its completion indicates dy the Government's hope is being realized: "...that facility will become an international focal point for and development in this increasingly important dis-

pproval has now been given for construction and f the National Research Council's Arctic Vessel and esearch Institute on the Memorial University cam- lers for construction of phase one will be opened ear. This important new institute will further reinforce on of St. John's as an internationally recognized ice research and cold ocean engineering. The e laboratory will exceed in physical dimensions any isting facilities and place Canada in a position of in this field.

Engineering Information Centre

specially designed, quarters were provided in the ilding for the Ocean Engineering Information Centre (OEIC). Although the principal purpose of the OEIC continues to be support of C-CORE and faculty ocean engineering research, it now more than ever is able to serve the local ocean engineering community and the Associates of C-CORE. During the year the OEIC undertook a contract study, on behalf of Fisheries and Oceans Canada, to identify papers and reports on ice, originating particularly within government, that were not being made available to researchers. Recommendations for action on a routine basis to include this material in Canadian data bases were accepted and are now being implemented.

The OEIC markets on a subscription basis the microfiche edition of its Index and the monthly 'OEIC Information Bulletin'. Revenue from this source and from charges for a variety of services provides a growing contribution towards the OEIC's annual operating costs. A C-CORE Data Bank has been set up by the OEIC to preserve and catalogue the varied and valuable field data that are collected in the course of each research project. The purpose is to ensure that this information continues to be readily available in useable form both to C-CORE and to the growing community of researchers in C-CORE's area of interest.

The Research Program

The graphic illustration — 'C-CORE Program: Past, Present and Proposed' — shows the evolution of the Centre's programs since its inception, and the level of expenditures required to support these operations. During the past year, the emphasis has been directed towards iceberg behaviour and seabed soil mechanics, radars and the oil and ice interrelationship. The need for further study of the behaviour of ice as a material and the investigation of ice/structure interactions has been identified and is still a C-CORE priority.

Seabed Engineering: The objective of one major program has been to investigate the influence of iceberg, wave and current stresses on bottom sediments in the Hibernia/Ben Nevis region of the Grand Banks, in order to estimate critical values for seabed stability. This work includes a regional geological survey, investigations of possible pipeline routes, a detailed site investigation of the Hibernia area, and the development of a probabilistic iceberg flux for the north eastern Newfoundland Shelf.

Another major activity undertaken in the past year has been the development of a submersible geotechnical corer. Large areas of the banks off the coast of Eastern Canada are covered with hard overconsolidated sediments. The retrieval of good undisturbed cores of the top few metres of these sediments is essential for developing accurate models of geotechnical characteristics and sediment transport, and for dating of iceberg scours. However, currently available shipborne corers and other devices have been unable to penetrate more than a few inches into this material. Accordingly, C-CORE undertook to design and build a diamond bit geotechnical corer which would operate from a platform resting on the seabed. This machine is now undergoing sea trials.

HF Radar: A preliminary assessment was made of the action required to bring to Canada the HF radar hardware and technology for remote surface current mapping. C-CORE undertook a feasibility study, for Fisheries and Oceans Canada, which concluded that the expertise exists within the Canadian community to bring this equipment into effective use for gathering information on the offshore regions. A very significant outcome of this initial study is the acceleration of C-CORE's research interest in adapting this type of radar sensor for the remote detection of ice hazards.

At the same time, the Centre has been operating an HF transponder station and receiving array in St. John's as part of a joint 'Over The Horizon' radar program with Ottawa's Communications Research Centre. The aim is to establish the feasibility of using HF skywave radar to monitor remotely, in near real time, ocean surface conditions, active weather systems, and possibly the pack ice edge.

The HF radar program, in all its aspects, has exciting potential and is likely to attract growing interest and support as its full significance for offshore operations begins to be understood.

Oil In Ice: The Centre has continued to play an active role in the development of oilspill countermeasures concepts and devices. Laboratory tests have demonstrated that a laser detector for the airborne identification of oil contamination in ice is a viable concept. A prototype system is being assembled for field testing. The concept of a heavy oil skimmer is being evaluated by C-CORE, the Canadian Coast Guard and CanOcean Resources Limited, with a view to the development of a prototype. Work is also in progress on the design and testing of concepts for the containment of subsea oil well blowouts and on an oil absorbing material for use in open water or broken ice conditions.

The surface drift card program initiated during the summer of 1979 has produced card returns in excess of 15%, almost entirely from the British Isles, with less than 0.1% return from Labrador. It was designed to quantify mean surface transport and the importance of its effect on the ultimate fate of spilled oil.

C-CORE, together with the Canadian Coast Guard, continued to participate in the further development of countermeasures training in St. John's for cold ocean oilspills. OCTU (Oilspill Countermeasures Training Unit) at the College of Fisheries, Navigation, Marine Engineering and Electronics gave the first presentation of its new course for potential on-scene commanders, which included case studies and a full-day simulated countermeasures exercise.

An offshore oilspill countermeasures seminar was held in St. John's in January. It reviewed the present state of technology for responding to offshore oilspills on the East Coast and established a context for further countermeasures research and development. The meeting was organized by the Environmental Protection Service, C-CORE, PetroCanada, Mobil Oil and Energy, Mines and Resources Canada.

Sea Ice Engineering: A program based in Makkovik, Labrador, collected ice movement data in order to evaluate theoretical models of fine-scale ice dynamics. These had been developed in order to provide insights into the interaction of ice and offshore structures. This work provides a basis for the further investigation of ice forces and ice/structure interactions.

An analytical and modelling study of iceberg motions in the Labrador Sea was completed by two faculty members from Memorial's department of Mathematics and Statistics, working with C-CORE while on sabbatical leave from the University. This study, in which a member of the Computer Science Department also participated, was directed towards the development of hazard forecasting systems.

A Workshop on 'Instruments and Techniques for the *In Situ* Measurement of Stress, Strain and Force in Ice' was held in St. John's at the outset of the year under review. It was jointly sponsored by C-CORE and by the Associate Committee on Geotechnical Research of the National Research Council.

The Centre also participated in a series of studies concerning year-round navigation into Lake Melville, Labrador. Its main concern was with the characteristics and dynamics of the offshore pack ice and the way in which it was likely to interact with any structures. The impulse radar, which was approved for commercial flying in December, was used to survey the Lake prior to the voyage into Goose Bay by the *M.V. Arctic*.

Research Plan

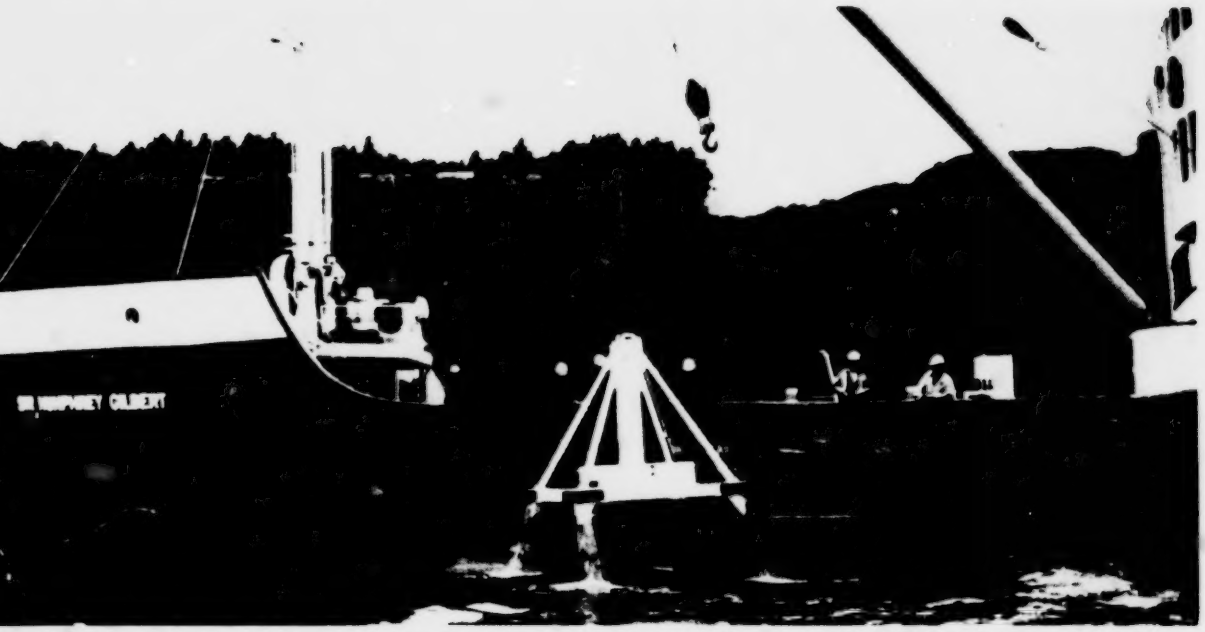
The outline plan endorsed by this Board that appears on page 8 of this report represents the current set of objectives toward which the Centre is working. It has evolved from the Research Plan set out in the 1979/80 Annual Report and is a product of the ongoing process of consultation and review referred to in the introduction to the plan. The Board believes that these objectives are practical and sound. It also considers that C-CORE's record to date provides a reasonable basis for expecting that the basic elements of its next five year plan can and will be achieved.

INSTRUMAR Limited

As foreseen in last year's report. INSTRUMAR Limited was incorporated by C-CORE in mid-1980 as a Newfoundland company to develop, make and sell high technology marine instruments on a commercial basis. Located in the Bartlett Building, INSTRUMAR has built up, during its first year, a staff of eight and a business with C-CORE and a variety of other organizations that appears to provide the basis for a viable commercial operation. The process of separating INSTRUMAR from the University has now been implemented.

Funding for C-CORE's Next Five Years

Following the Centre's first two years of operation, which were almost wholly funded by grants from the Devonian Group of Charitable Foundations, government and industry were approached with a proposal to provide sustaining funding for the Centre over the subsequent five year period. The positive response to this proposal resulted in the receipt of significant government and industry contributions to the funding of the



itial sea trials of the submersible geotechnical corer developed by C-CORE were run from the *CCGS Sir Humphrey Gilbert*. deployment was diver assisted in the lee of Bell Island, Newfoundland, but subsequent operations in more open water carried out unassisted.

core research program and substantial additional nds from Devonian. As is apparent from the illustration 9, there has been a steady buildup in C-CORE's level tions and in its annual budget, which is now in the $1.5 million.

earlier proposal foresaw the need to renew funding in ent year. Having achieved the main objectives of the plan, the Centre recently made a further approach to nt and potential supporters with a proposal for the d funding of C-CORE over the next five years. In order ain the present level of activity and provide for some wth, the Centre will have to find income from all of approximately $12 million over the five year period. d over the whole period, $2.4 million will be required t has been proposed that the federal government and would each contribute $1.2 million annually to 's research. Part would be in the form of unrestricted ds and the balance in restricted funds designated for programs or projects within fields related to the core program, as defined in the Research Plan.

initial response has been most encouraging, particu- n those Canadian companies that have a major inter- ontier exploration and production.

cial

report contains the audited financial statements for r ended March 31, 1981 and the Auditor's Report d by the Auditor-General of Newfoundland.

ORE's operating account position for the year under s presented in the current report in the accompanying Sheet and Statement of Revenue, Expenditure and all of which have been prepared on an accrual basis. nent showing the position of the C-CORE Research at March 31, 1981 is included in this report. It shows Trust, which stood at $1,970,340 at the beginning of the year under review, received contributions during the year of $367,500 and interest was credited to it of $207,859 for the period. The release and transfer from the Research Trust to operating account of $1,200,000 was authorized to cover the Centre's core operating expenditures. A further $303,555 was received from contracts, contributions to programs and other sources and credited to operating account, resulting in total revenue for the year of $1,503,555. Expenditures for the year were $1,345,298, resulting in an excess of revenue over expenditure for the year of $158,257 and a conversion of the deficit carried forward at the beginning of the year to a surplus of $19,643 at the year end.

In addition to cash grants, contract revenue and other receipts, C-CORE also received in 1980/81 support-in-kind to an estimated value of $1,500,000 of which approximately $230,000 represented accomodation, facilities, services and equipment provided by Memorial University.

For the 1981/82 fiscal year, the Centre has budgeted capital and operating expenditures of $1,500,000 and income from all sources of $1,550,000. The Board of Governors has authorized the release from the Research Trust of up to $1,300,000 to cover core operating expenditures during the year.

Current revenue forecasts indicate that contributions into the C-CORE Research Trust in 1981/82 may be approximately equivalent to the probable drawdown from the Trust.

A. A. Bruneau
Chairman

H. L. Snyder
Director

Research Plan — 1981/82

Introduction

In the broadest terms the main thrust of the Centre's activity will continue to be focussed on ice in our northern oceans, its occurrence and behaviour, and the problems it presents to engineering designers and systems operators.

The precise goals of the Centre's program are frequently reviewed and assessed by the staff both with the Research Program Advisory Committee of the Board of Governors and with industry representatives from the Associates to ensure that its resources are most productively deployed in the light of emerging needs and anticipated developments. In the following sections current plans for the next five years or so, are presented in relation to forecast development needs.

Relation of Research Plan to Forecast Resource Developments

There is an urgent requirement for engineers to know the loads and incidence of hazards attributable to sea ice and icebergs in order to design safe, economic structures and systems. It is this gap that must be closed before large scale development can proceed. C-CORE perceives this as being basic and a significant part of its research effort will continue to be directed to improving this definition.

1. Engineering Specification of Loads and Risks

Defining the magnitude of ice and storm loads is the prerequisite to making the decision on how to build a structure which can survive severe climatic conditions and forces or one that is designed to avoid those hazards. While this decision will be based on economics, safety considerations will be paramount.

Sea Ice Mechanics: There are basic aspects of ice mechanics that require imaginative new directions. Fundamental analytical skills need to be developed if the deformation of ice and the forces generated within the pack are to be described quantitatively. The formulation for dynamic ice behaviour has received considerable attention by geophysicists attempting to describe this process on a global scale. However, many of the assumptions that are relevant at the large scale are not appropriate when describing ice pressures on vessels and local forces at the interface between ice and a structure.

A preliminary review of the state-of-the-art modeling techniques presently being applied in macro ice dynamics indicate that a different approach must be taken if engineering answers are to be provided. Of particular significance are the rheological considerations and the constitutive laws governing the material response which assumes that ice acts as a continuum. A major short-coming in attempting detailed analytical work in this field is the virtual absence of data describing the stress levels within the ice pack. To date, the bulk of the ice modeling work at C-CORE has been directed toward establishing an appropriate formulation of the driving forces resulting from winds and ocean currents coupling to produce the loads that the ice pack can exert on a structure.

Measurement of Forces in Sea Ice: The critical need is for field data measuring a realistic loading environment. A practical way of approaching this problem may be to instrument ice interacting with islands or headlands. Simulation experiments of this kind will provide ice loading data which should be applicable to structures subjected to the same conditions. The initial step must be to develop instrumentation systems and techniques to obtain this information. The ability to interpret the level of stress developed in pack ice will provide access to the design tool of stress analysis used by the engineer as standard practice when employing more conventional materials. These can normally be referenced for strength and other key properties in the relevant engineering manuals.

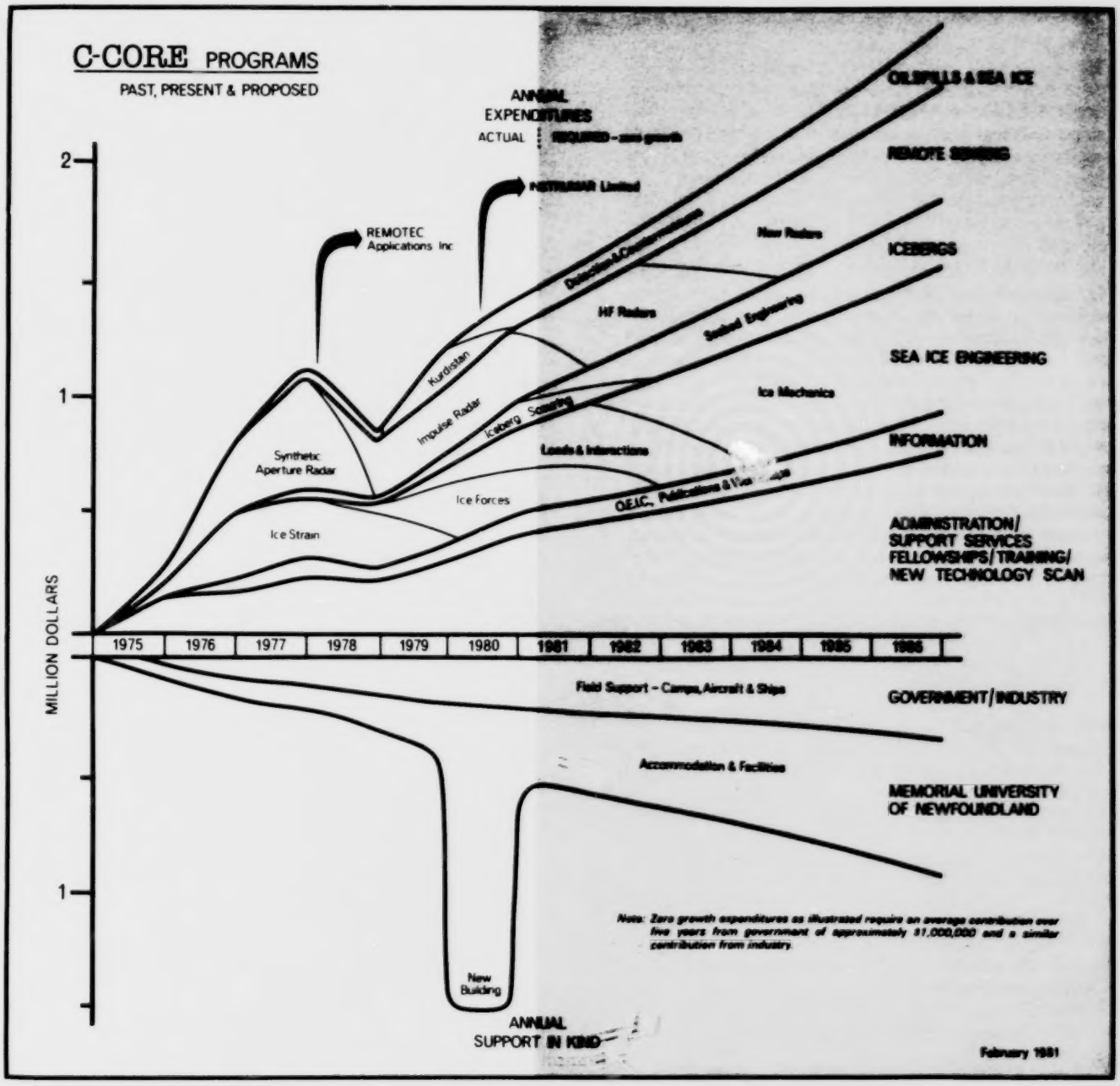
Until reliable information of this kind becomes available, it will not be possible to ensure that the design of structures for the northern offshore environment is both safe and economic. This process of optimization will determine the pace of Canadian frontier resource development.

Ice as a Construction Material: Utilization of ice as a structural material is already standard engineering practise. The construction of roads, air strips and drilling platforms has been common in the Canadian north for many years. Current development activity, particularly in the Arctic, provides an opportunity and an incentive for optimizing these applications and extending them. Examples are the construction of island platforms from a combination of ice and sediment, and the enhancement of permafrost growth upward to stabilize foundation material.

Ice strength control techniques must be further developed to ensure the predictable behaviour of ice when used as a structural material. These will include better control of the growing and forming process, improving the efficiency of brine drainage, new additives and reinforcement techniques, thermal regulation of strength and innovative use of insulation and temperature control. Tackling these problems is a logical extension of C-CORE's present research program.

Iceberg Collision Avoidance: There is a need to develop the capability of determining the risk of an iceberg collision, at specific sites throughout the eastern Arctic and off the East Coast. The estimation of the forces applied to an engineering structure colliding with an iceberg is a reasonably straight forward application of momentum transfer. However, the engineer is still lacking reliable information on iceberg population dynamics with which to estimate the probability of an iceberg impact. Building up statistics, particularly of the incidence of extreme events, requires large samplings to establish confidence in the form of the distribution and flux of the iceberg population. This information must then be interpreted and integrated with the design needs of the operator.

The final selection of structure and system type will depend on the choice between designing them to survive possible impacts or to avoid such hazards. It will therefore be necessary to determine first if it will be economic to build permanent structures capable of withstanding collision with an iceberg of credible proportions. If this is not feasible, then an alternate system must be devised that is capable of avoiding this hazard. C-CORE will continue to participate in the development of this overall picture and in deriving from it design guidelines for structures that are exposed to this risk.



Marine Sediment Gouging by Icebergs: The risk of impact on seabed installations by grounding icebergs is an equally important concern. Initial side scan sonar reconnaissance of portions of the seafloor throughout the eastern offshore area shows a cumulative record of scours. It is not yet known how many of these scours were made quite recently or which are relics of the past 10,000 years.

The sediment transport studies now in progress on the Grand Banks will throw light on the operative processes. Once it becomes possible to estimate the period over which a scour mark is erased, it would then be a relatively simple task to estimate the date of individual scours from the shape and erosion features of the scour trench and displaced material. In this way, a measure of the scouring frequency could be derived.

High resolution seismic systems, remotely operated subsea cameras and sediment corers may provide the means for securing this information. Over-compacted sediments and glacial deposits on the northeastern continental shelf make it difficult to secure geotechnical samples with presently available equipment. Accordingly, C-CORE is developing a corer to obtain undisturbed samples of seabottom material and will continue to develop new instrumentation, designed to operate reliably in the cold ocean environment.

2. Remote Identification and Measurement

There is an ongoing need for environmental information during operations that is quite distinct from the requirement for basic data on loads and risks that arise in the system design phase. Such environmental data is required as a basis for long range forecasts used in advance planning, monitoring of hazards and prediction of hazard trajectories. Among the hazards encountered in northern offshore waters are pack ice, large or thick floes including multi-year ice, ice ridges, icebergs and glacier debris. There are also the general hazards associated with ocean waves, storm centres, moving vessels and mobile structures particularly in the marginal ice zone.

Seasonal Ice Forecasts: A prerequisite for the production of seasonal ice forecasts is the environmental data base containing information on ice formation, ice budget and ice transport. It is the quality of these data that determines the effectiveness of management decisions. C-CORE has done some work towards assessing the information on which current forecasts are made and the effectiveness of the presently available data collection systems. Some of the input components are long term weather forecasts, a residual ice cover, rate of change in sea surface temperature, cumulative ice growth and directional trends in surface winds.

From these data sources, it is now possible to produce a preliminary seasonal ice forecast and a rudimentary service of this kind is already being offered by some environmental consulting firms. Advances in sensor, communications and data processing technologies, and the introduction of certain new satellite and meteorological programs will contribute to a significant increase in the quality of the data on which ice forecasts are based.

Measurement by HF Radar: C-CORE has been engaged in development work related to a number of these objectives. Remote identification of ice and sea state, as well as other environmental conditions, is still in a development stage. Active sensors, such as radar, offer a distinct advantage compared to passive optical systems, in their ability to see through cloud, fog and precipitation. They are therefore well suited to the offshore regions where fog and storm conditions are normal.

A recent development which has exciting potential for ocean remote sensing is in the field of high frequency (HF) Doppler radar which has been applied to measure and map a number of ocean parameters. A computer is used to handle and sort the large volume of radar backscatter data in the frequency domain. It then becomes possible to interpret wave directions and surface current velocities through Doppler processing. Frontline research in this field is now directed at measuring the wave height spectrum and thus quantifying sea state.

The return from the diffraction grating provided by the ocean wave pattern (Bragg scattering) is a basis for measurement by HF radar. Therefore, to the extent that the ocean is covered with ice, the modified return will be absent. This should make it possible to trace the position of the ice edge. It is still to be determined whether ground wave HF radar is capable of detecting leads within an area of pack ice.

The recent dramatic reduction in the size of HF radar antennas has been due to new developments in antenna design and innovations in the use of real-time computer processing (for beam steering) on the radar return. This has made it possible to construct a portable ground wave HF radar system called Coastal Ocean Dynamics Application Radar (CODAR).

In assessing the suitability of the system for Canadian remote sensing applications, it will be necessary to find answers to a number of questions. These include determining if it is feasible to compensate for antenna motion so that HF radar antennas could be mounted and operated from vessels, buoys or offshore platforms. In this way surveillance of the ocean surface could be maintained well beyond the range of present shore based stations.

Iceberg Track Prediction: Before an iceberg trajectory can be predicted with acceptable confidence, a spatial description of the ocean current field must be available. The ground wave HF radar can provide a description of the surface current structure and, by calculation and interpretation, the current profile at depth. Because ocean dynamics is a very complex subject, a model based on accurate real-time information is more likely to produce reliable projections. These could contribute to an effective ice management system.

3. Environmental Impact on Forecast Resource Development

Knowledge of the ice regime of the northeastern offshore, and of the Arctic, is of critical importance to understanding the probable impact on the environment of forecast resource development in these regions. It is also basic to planning effective countermeasures for oilspills or related accidents. Oil industry contingency plans involve the initiation of remedial action, accompanied by containment and recovery operations. All of these activities, as presently conceived would be hindered or prevented by ice. It may not be possible to put a rig on station to drill a relief well in the case of a blowout. Deployment of containment booms is not feasible in the presence of pack ice. Presently available recovery equipment does not operate effectively in high seas or in ice.

Research efforts in this field have concentrated on the development of new countermeasures equipment and techniques and on devising methods for identifying and tracking oil. C-CORE's own work in this area has been directed to the interface between oil and ice and, in particular, to assessing the effects of a major oilspill resulting from a serious tanker accident off Newfoundland. It has also directed effort to the development of remote sensing methods for the identification of oil in ice and towards evolving new countermeasures that will operate effectively in pack ice.

Detection of Oil in Ice: The initial requirement in the event of an oilspill is to locate the oil and map its surface distribution. C-CORE demonstrated in the Arctic that ground based impulse radar can identify oil underlying an ice cover. Further evaluation work and field tests are required to complete the development of this radar system and its optimization as an instrument for the detection of oil under, or layered within, ice.

A complementary project is underway for the airborne identification of oil in broken ice. This involves an attempt to measure the thermal sensitivity of oil in such ice conditions. Energy from an infra-red laser source heats the oil and the relative radiant temperatures of the oil and of the colder ice surface are measured by an airborne infra-red line scanner.

Much still needs to be done in developing reliable instrumentation for identifying oil in a variety of cold ocean conditions.

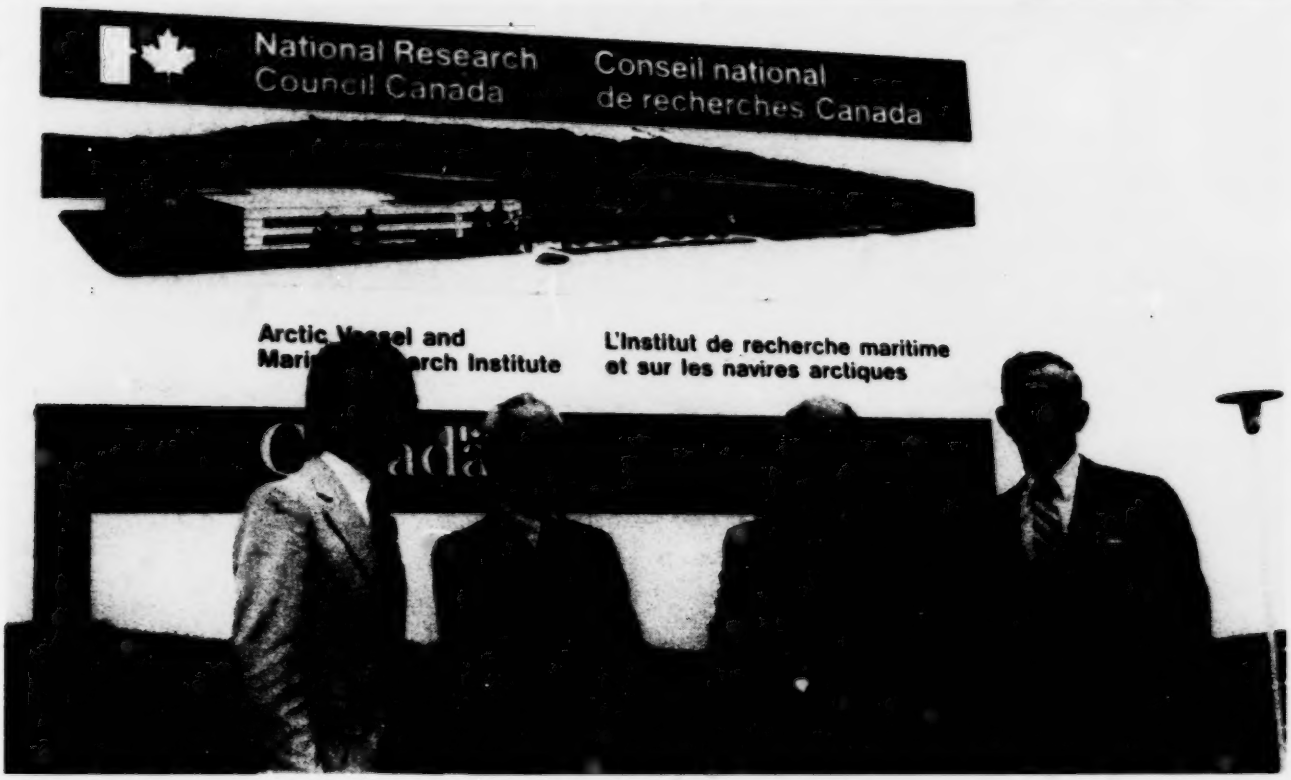
Oilslick Tracking: The ground wave HF radar system also has application for tracking oil in an open ocean environment. It has excellent potential for replacing the various slick tracking models or simulators on which government and industry currently rely. Information could be provided from this source on the speed and trajectory of the oil slick as a basis for countermeasures planning.

Oil Dispersion in Pack Ice: Characterization of oil dispersion in pack ice demands research effort. In order to achieve a better understanding of the dispersion rates of oil through or within an ice cover, it will be necessary to establish the mixing processes which are operative for various ice types. A compact anemometer, using an electrochemical transducer, is under development by C-CORE and INSTRUMAR Limited. This instrument was conceived as a means of measuring water circulation within loosely packed ice. It is these flows that disperse spilled oil within the pack and contribute to its dispersion over a wide area.

Countermeasures Development: New directions will have to be taken if countermeasures devices and techniques, capable of producing acceptable results in ice, are to be developed. One idea that has already been endorsed by industry operators is the proposed development of an oil scavenger material. C-CORE researchers have been experimenting with a buoyant oleophilic material which, when deployed on an oil slick or oil-in-ice mixtures will act to absorb the oil. Once its own buoyancy has been reduced, it will sink and be incorporated into the seabed sediments. In the event of an oilspill within or beneath an ice cover, this scavenger material would spread with the slick and continue to absorb oil as the ice melted. Once this had occurred the material would have become too dilute for it to be collected in any conventional recovery operation.

Countermeasures Equipment: The Centre's close working relationship with the Marine Emergencies Division of the Canadian Coast Guard's Newfoundland Region has lead to liaison in countermeasures equipment development. Out of this cooperation has grown a design concept for an oil skimmer capable of operating in high sea states. Another concept being evaluated is for an oil trawl. Thus C-CORE has initiated the development of concepts and it is involved in the establishment of their initial feasibility. The subsequent stage of fabrication and marketing would be undertaken by the industrial sector.

Another development where C-CORE proposes to play an active role is in the initial engineering for a contingency unit designed to contain a well-head blowout at the drill site. The concept envisages a seafloor collection header with ducting to a surface disposal device. This would be designed to break through the ice above or to underride it. As oil could be neither moved nor stored during the ice season, it would be disposed of through burning. This would restrict environmental damage to the blowout area where a subsequent clean-up operation would be manageable.


National Research Council Canada
Conseil national de recherches Canada
L'Institut de recherche maritime et sur les navires arctiques

The sod-turning ceremony for the National Research Council's Arctic Vessel and Marine Research Institute took place on May 29, 1981. Left to right: the Hon. Leo D. Barry, Minister of Mines and Energy, Government of Newfoundland and Labrador; Dr. Larkin Kerwin, President, National Research Council of Canada; the Hon. William Rompkey, Minister of National Revenue; and President M. O. Morgan, Memorial University of Newfoundland.

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
BALANCE SHEET
AS AT MARCH 31, 1981

	1981	1980
Assets		
Accounts Receivable	129,120	108,232
Due from Instrumar Limited (Note 2)	64,547	—
	193,667	108,232
Fixed assets-at cost	292,457	227,746
Less: Accumulated depreciation	169,936	111,316
	122,521	116,430
Total assets	316,188	224,662
Liabilities And Surplus		
Accounts payable and accrued liabilities	22,253	41,640
Interest-free advance from Memorial University of Newfoundland with no specific terms of repayment	274,292	321,636
Total liabilities	296,545	363,276
Surplus Deficit	19,643	(138,614)
Total liabilities plus surplus	316,188	224,662

See accompanying notes

Signed on behalf of the University

Chairman of the Board of Governors

Comptroller of the Memorial University of Newfoundland

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
STATEMENT OF REVENUE, EXPENDITURE AND SURPLUS
FOR THE YEAR ENDED MARCH 31, 1981

	1981	1980
Revenue		
Research Trust	1,200,000	930,000
Research contracts	227,194	369,307
Other	76,361	21,331
Total revenue	1,503,555	1,320,638
Expenditure		
Staff salaries	717,525	602,506
Research program	347,982	410,906
Support services	97,448	102,406
Contribution to equipment - new C-CORE Building	—	100,000
Ocean Engineering Information Centre	79,414	70,650
Fellowships	58,154	43,991
Board of Governors	44,775	19,509
Total expenditure	1,345,298	1,349,968
Excess of revenue over expenditure for the year	158,257	(29,330)
Deficit 1 April	(138,614)	(109,284)
Surplus (Deficit) 31 March	19,643	(138,614)

See accompanying notes.

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
NOTES TO FINANCIAL STATEMENTS
FOR THE YEAR ENDED MARCH 31, 1981

1. **Accounting Policies**

(a) Transactions are recorded in the financial statements of the Memorial University of Newfoundland on a cash basis. However, subsidiary records maintained by the Centre's staff have been used to present these financial statements on an accrual basis.

(b) Depreciation is calculated on a straight line basis as follows:

Equipment	5 years
Tools and Marine Equipment	2 years
Computer software and other equipment	1 year

2. **Instrumar Limited**

Instrumar Limited was incorporated under the provisions of the Newfoundland Companies Act on 24 July 1980. Prior to this incorporation operations now done by Instrumar Limited were performed by the Centre and included in its financial statements.

The operations performed by the Centre on behalf of Instrumar Limited and included in the financial statements for the year ended 31 March 1981 is that portion of revenue and expenditure, amounting to $4,810 and $21,473 respectively, which occurred between 1 April 1980 and 24 July 1980.

The receivable amounting to $64,547 is the net expenditure by the Centre on behalf of Instrumar Limited for the period 24 July 1980 to 31 March 1981.

3. **Funds in Research Trust**

Cash transactions in the Research Trust were as follows during the year:

Balance at bank, 1 April 1980	$1,970,340
Receipts:	
Industry	167,500
Government of Canada	200,000
Investment Income	207,859
	575,359
Less: Transferred to the Centre's operations	1,200,000
Net contribution during year	(624,641)
Balance at bank, 31 March 1981	$1,345,699

4. **Support-in-Kind**

Management has estimated the cost of various services provided without charge by Memorial University of Newfoundland, the Government of Newfoundland and Labrador and other agencies at $1,500,000, for the year ended 31 March 1981. ($250,000 — 1980)

DEPARTMENT OF THE AUDITOR GENERAL
ST. JOHN'S, NEWFOUNDLAND

AUDITOR'S REPORT

The Board of Regents,
Memorial University of Newfoundland,
St. John's, Newfoundland.

I have examined the balance sheet of the Centre for Cold Ocean Resources Engineering as at 31 March 1981 and the statement of revenue, expenditure and surplus for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Centre as at 31 March 1981 and the results of its operations for the year then ended in accordance with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

J. F. McGrath, C.A.
Auditor General

St. John's, Newfoundland
29 July 1981

C-CORE
CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
MEMORIAL UNIVERSITY OF NEWFOUNDLAND
ST. JOHN'S, NEWFOUNDLAND, A1B3X5,CANADA
TELEPHONE (709) 737-8354

Reports and Publications for 1980

80 -1 Reimer, E. "The Visual Identification of Bunker C Oil in Dynamic Pack Ice." Preprint for the Kurdistan Workshop, Dartmouth, N.S. 12 pp., June 1979.

This publication is not available from C-CORE, but is included in publication 80-2.

80 -2 "An Oilspill in Pack Ice." Contract Report, 231 pp., January 1980.

The work covered by this report was executed for the Arctic Marine Oilspill Program of the Environmental Protection Service. Requests for copies should be directed to: Environmental Emergency Branch, Environment Canada, 15th Floor, Pl. Vincent Massey, Ottawa, Ontario, K1A 1C8.

80 -3 Barrie, J.V. "Iceberg-Seabed Interaction (Northern Labrador Sea.)" Annals of Glaciology, Vol. 1, No. 1, 1980, 20 pp.

80 -4 Laidley, T.E. "An Analysis of the Application of Borehole Logging Techniques to the Study of Sea Ice." Technical Report, 45 pp., April 1980.

80 -5 Rossiter, J. R. and Bazeley, D. P. (eds.) "Proceedings of the International Workshop on the Remote Estimation of Sea Ice Thickness, St. John's, Newfoundland, September 25-26, 1979." Conference Proceedings 505 pp., May 1980.

80 -6 Rossiter, J.R., Butt, K.A., Gamberg, J.B., and Ridings, T.F. "Airborne Impulse Radar Sounding of Sea Ice." Preprint for the 6th Canadian Symposium on Remote Sensing, May 21-23, 1980, Halifax, N.S., 8 pp.

80 -7 Langhorne, P., Rossiter, J.R., and Keliher, T.E. "Remote Estimation of Sea Ice Properties, Ice Core Analysis, Beaufort Sea, March 1979." Data Report, 171 pp., July 1980.

80 -8 Laidley, T.E., Laurentius, T.B., and Hamza, H. "A Load Bearing Capacity Test on a Freshwater Ice Cover." Technical Report, 50 pp., August 1980.

80 -9 "C-CORE Annual Report 1979-80." 20 pp., September 1980.

80-10 Whittick, J.A. "Offshore Engineering Information Sources." Presented to the Second National Offshore Information Conference, London (England), September 26, 1980. 34 pp.

80-11 "Multi-Year Ice Thickness Distribution in the Beaufort Sea Determined by Impulse Radar." Contract Report, October 1980.

This report is proprietary to Canadian Marine Drilling Ltd. and to Esso Resources Ltd. until January 1, 1982.

80-12 Reimer, E. and Goobie, G.I. "Remote Sensing of Oil in Pack Ice." Presented to the Workshop on Research in the Labrador Coastal and Offshore Region, Goose Bay, Labrador, September 4-6, 1980. 21 pp.

80-13 Lewis, C.F.M. and Barrie, J.V. "Ice Scour Studies on the Labrador Shelf." Presented to the Workshop on Research in the Labrador Coastal and Offshore Region, Goose Bay, Labrador, September 4-6, 1980. 2pp.

80-14 Swaters, G.E. "A Note on Dynamic Ice-Ocean Interaction." Submitted to the Journal on Geophysical Research. 16 pp., October 1980.

80-15 Roche, C.M. "Iceberg Tracking Program, Pointe Amour, Labrador — Final Report." Technical Report, 71 pp., October 1980.

80-16 Gaskill, H.S., Lopez, R.J. and Swaters, G.E. "Free Drift of Sea Ice: A Comparison of Models." Technical Report, 132 pp., October 1980.

80-17 Amos, C.L. and Barrie, J.V. "Hibernia and Ben Nevis Seabed Study — Polaris V, June 1980." Data Report, 44 pp., October 1980.

80-18 Rossiter, J.R., Butt, K.A. and Mercer, J.B. "Impulse Radar Profile over T3". Presented to the Final SURSAT Ice Applications Workshop, Toronto, June 23-27 1980. 10pp.

80-19 Grenville, D.M. and Strong, J.J. "OCTU, St. John's, Newfoundland--A Joint Venture Training Program." Presented to the 1981 Oil Spill Conference, Atlanta, Georgia, March 3-5 1981. 10pp.

80-20 Reimer, E.M. "Anticipated Oil Dispersion Rates in Pack Ice". Presented to the 1981 Oil Spill Conference, Atlanta, Georgia, March 3-5 1981. 10pp.

80-21 "Proceedings of the Workshop on Sea Ice Field Measurement, St. John's, April 29-May 1, 1980". Conference Proceedings, 362pp., December 1980.

C-CORE
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ST. JOHN'S, NEWFOUNDLAND, A1B3X5,CANADA
TELEPHONE (709) 737-8354

Reports and Publications for 1981 (to September)

81- 1 Winsor, W.D., Jackman, M. and Power, G. "Cruise Report Ice Feature Observations from the CCGS Franklin, Summer 1979." Data Report, 107 pp., February 1981.

81- 2 Ball, P., Gaskill, H. S. and Lopez, R. J. "Iceberg Motion: An Analysis of Two Data Sets Collected at Drill Sites in the Labrador Sea." Technical Report, 121 pp., April 1981.

81- 3 Goobie, G. I., Laidley, T. E. and Reimer, E. M. "C-CORE Oilspill Research". In Proceedings of AMOP Conference, Edmonton, June 16-18, 1981.

81- 4 Reimer, E. M. (ed.) "Subsurface Oil Movement off the Newfoundland South Coast During 1979." Data Report, 98 pp. April 1981.

81- 5 Butt, K. A. and Reimer, E. M. "Presentation of an HF Radar Development Program to the Eastern and Arctic Petroleum Operators Associations." 28 pp. May 1981.

81- 6 Allan, A. J. and Bazeley, D. P. (eds.) "Test Platforms for the Measurement of Ice Forces." Technical Report, 220 pp., May 1981.

81- 7 Reimer, E. M. "Nearshore Surface Current Delineation, Cape Hatt, 1980." Data Report, 29 pp., May 1981.

81- 8 Lewis, C. F. M. and Barrie, J. V. "Geological Evidence of Iceberg Groundings and Related Seafloor Processes in the Hibernia Discovery Area of Grand Bank, Newfoundland." In Proceedings of the Symposium on Production and Transportation Systems for the Hibernia Discovery, St. John's, February 17-19, 1981. In press.

81- 9 Ball, P., Gaskill, H. S. and Lopez, R. J." Environmental Data Requirements for a Real Time Iceberg Motion Model." In Proceedings of the 6th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC 81) Quebec City, July 27-31, 1981, Vol. III (in press).

81-10 "Subsea Containment." Contract Report for Dome Petroleum Ltd. 65 pp., August 1981.

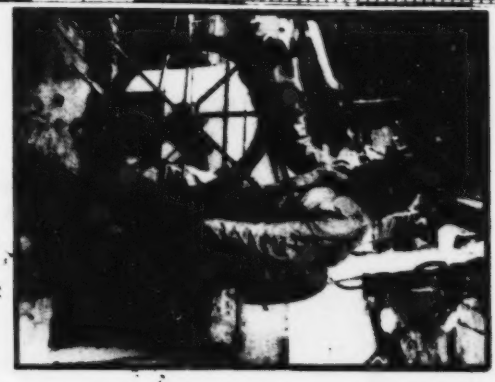
81-11 "*MV Arctic* Lake Melville Probe 1981. Airborne Impulse Radar: Uses and Limitations as an Ice Navigation Aid on Lake Melville. Contract Report for Melville Shipping Ltd. 14pp., August 1981.

Availability of C-CORE Publications

'Technical Reports', 'Data Reports' and 'Conference Proceedings' are normally available from C-CORE. The availability of 'Contract Reports' is noted individually. Preprints of papers presented by C-CORE members to external meetings or submitted to other publications are available from C-CORE, unless timely external publication is expected.

PILOT CHART
OF THE
NORTH ATLANTIC OCEAN
MARCH 1937

C-CORE
CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
MEMORIAL UNIVERSITY OF NEWFOUNDLAND
ST. JOHN'S, NEWFOUNDLAND, CANADA A1B 3X5



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ST. JOHN'S NEWFOUNDLAND

GRAND BANKS

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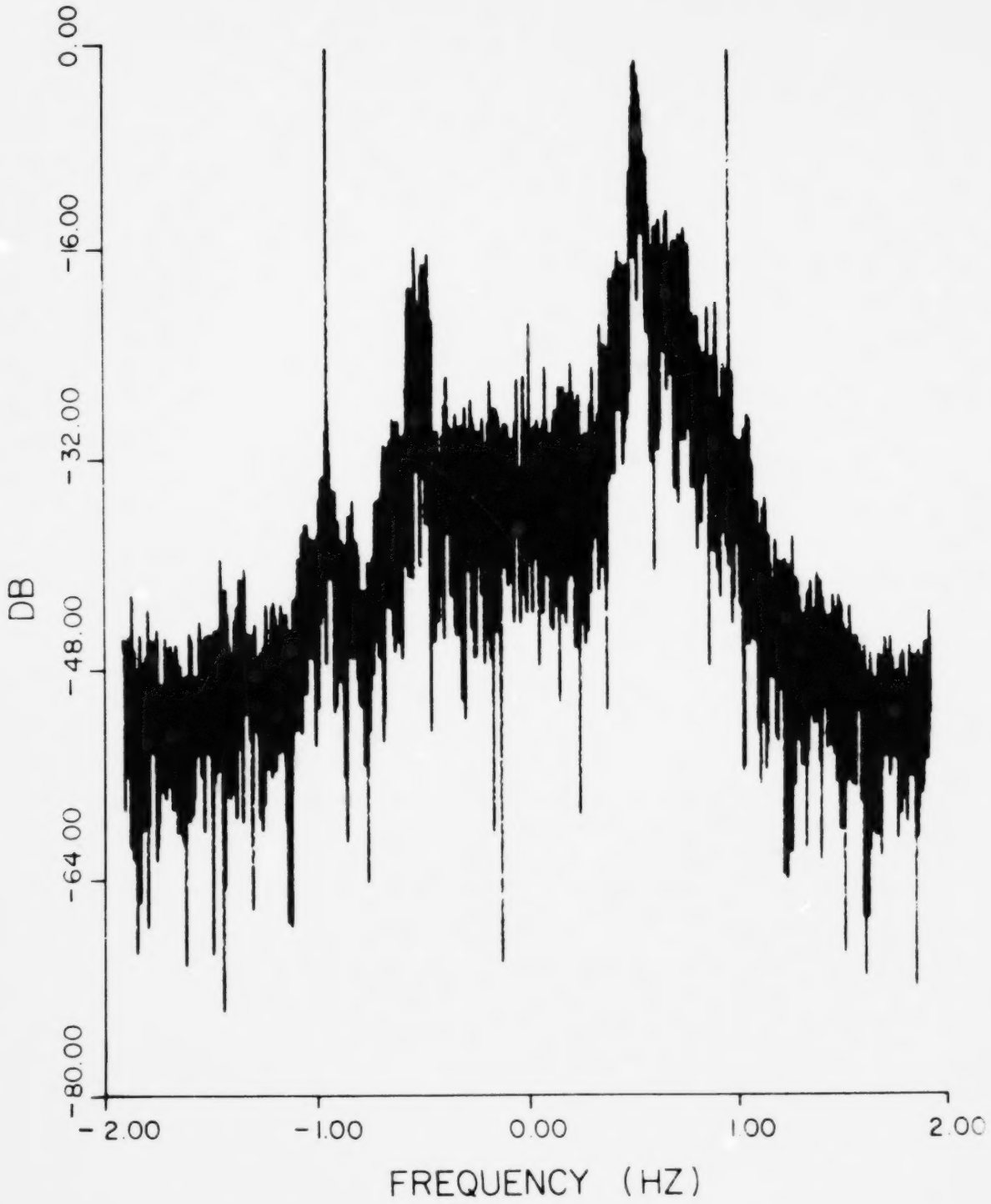
C-CORE Annual Report 1981-82



Antenna: 1 Range Cell: 6
Run Time: 23-FEB-82 15:30

Latitude: 46 51 40
Longitude: -52 56 45

Extracts from C-CORE's Constitution

"ARTICLE IV PURPOSE

The purpose of C-CORE shall be to undertake engineering research designed to assist in the safe and orderly development and utilization of Canada's ocean-related resources."

"ARTICLE V ORGANIZATION

Board of Governors

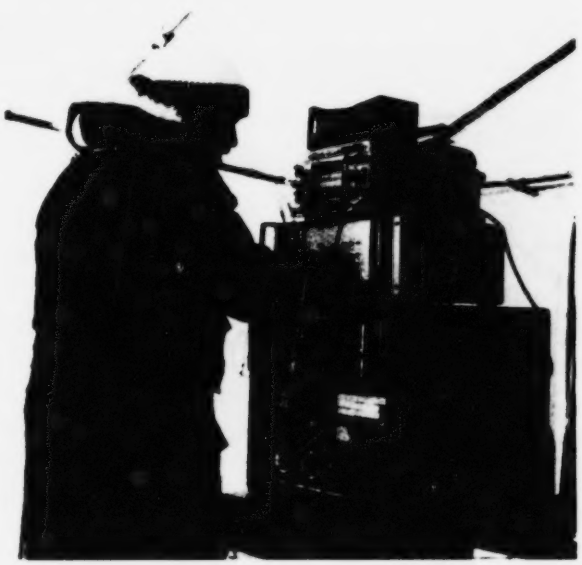
C-CORE is a self-reliant organization of Memorial University which is owner of C-CORE's buildings and equipment and beneficiary of all its assets and liabilities. The Board of Governors is responsible for the funding, research activities, policy direction and management of C-CORE."

"ARTICLE VI FINANCIAL ADMINISTRATION

c) C-CORE Research Trust

All the incoming funds which have been designated as contributions to C-CORE's research programs shall continue to be deposited for credit to the C-CORE Research Trust. The Comptroller of Memorial University administers the C-CORE Research Trust on behalf of the Trustee, the Board of Regents of Memorial University. Following approval of budgets and current operating financial statements, the Board of Governors shall recommend to the Trustee the release of funds from the Trust to the C-CORE capital and operating accounts. The Trustee shall manage and invest Trust Funds to the benefit of the C-CORE Research Trust."

Cover: The plot of a CODAR Doppler spectrum. These data contain information on significant aspects of the ocean surface from which the HF radar signal was reflected. From this first deployment of C-CORE's CODAR equipment at Cappahayden, Newfoundland, surface current component vectors at ranges out to 40 kilometres. The two spikes are the signature of a Doppler transponder.



Above: the CODAR system was used in March to collect data on the ground wave transmission of HF radar signals over sea ice at Pond Inlet, N.W.T.

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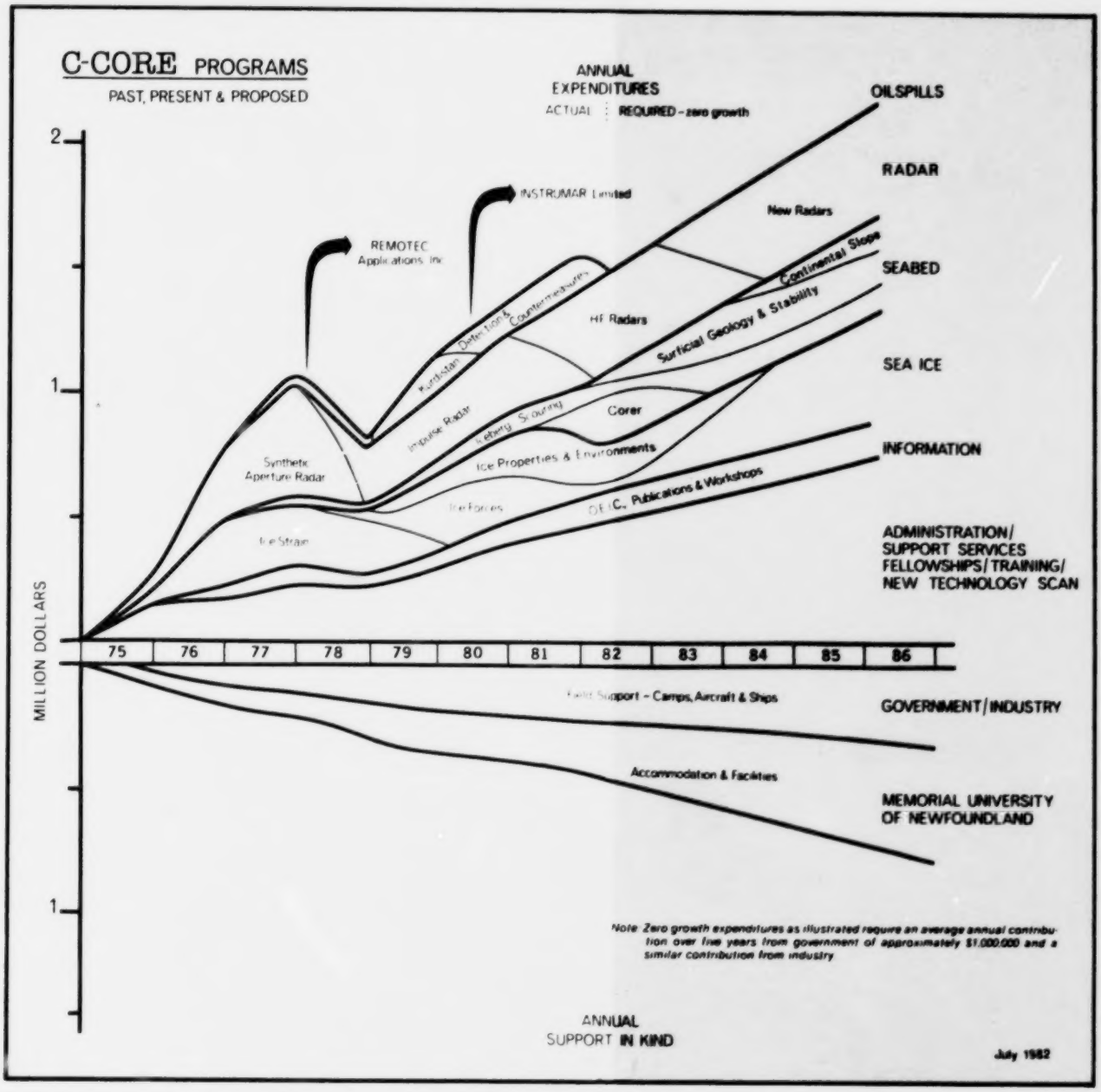
C-CORE Publication 82-D August 1982



The graph above shows the basic distribution of funds between C-CORE's major research areas during the last seven years, together with the level of support in kind. The projection side shows the annual funding required to maintain the present level of activity.

C-CORE Field Programs 1981-1982

August 1981	Cape Hatt, Baffin Island	Oilspill dispersant trials
October	*Pandora II*, Labrador Sea	Submersible observations of iceberg scouring and seabed geology
	CSS Hudson, NW Passage	Seabed investigations
	Torbay, Newfoundland	Oilspill dispersant trials
December	Cape Spear, Newfoundland	First test, radar grey level enhancement
February 1982	Cappahayden, Newfoundland	Single site CODAR test
	Pond Inlet, NWT	Ice properties measurement
March	Pond Inlet, NWT	HF propagation tests over sea ice
	CCGS Franklin, Lake Melville	Winter probe
April	Cape Norman, Newfoundland	Ice observation with radar enhancement system
	MV Brandal, Sable Island	Seabed investigations
May	Tarsuit Artificial Island Beaufort Sea	Ice movement monitoring using radar enhancement system

In October 1981, the manned submersible *Pisces IV* was used to examine iceberg scouring and seabed geology on the Labrador Banks and in the Strait of Belle Isle. The *Pisces* is shown here being launched from its tender vessel the *Pandora II*.

BEAUFORT SEA
BAFFIN BAY
Cape Hall
DAVIS STRAIT
LABRADOR SEA
LABRADOR

Board of Governors

Dr. A. A. Bruneau, Chairman
President, Bruneau Resources Management Limited

Professor C. D. diCenzo*
Dean of Engineering & Applied Science
Memorial University of Newfoundland

Mr. H. M. Clarke*
Deputy Minister
Department of Development
Government of Newfoundland & Labrador

Dr. A. E. Collin**
Associate Deputy Minister
Energy, Mines and Resources Canada

Dr. W. Denner
Former Director
Newfoundland Institute for Cold Ocean Science
(retired November, 1981)

Mr. G. N. Ewing**
Assistant Deputy Minister
Ocean Science and Surveys
Fisheries and Oceans Canada

Mr. G. R. Harrison**
President, Canadian Marine Drilling Ltd.

Mr. E. F. Hewlett*
Chief Executive
Hewlett Group of Companies

Mr. A. Janisch
Former President & Chief Operating Officer
Petro-Canada
(retired March, 1982)

Mr. D. G. Little
Former President & General Manager
Mobil Oil Canada Ltd.
(retired November, 1981)

Mr. H. Lundrigan*
Senior Vice-President
Lundrigan's Limited

Mr. W. Mason*
President & General Manager
Mobil Oil Canada Ltd.

Mr. S. T. Mathews
Institute Director
Arctic Vessel and Marine Research Institute
(retired March, 1982)

Dr. R. Pottie*
Atlantic Regional Director
National Research Council of Canada

Dr. R. F. Shaw
Consultant
Montreal Engineering Company Ltd.
(retired March, 1982)

Mr. H. L. Snyder
Director
Centre for Cold Ocean Resources Engineering

Mr. D. M. Grenville, Secretary
Former Administrator
Centre for Cold Ocean Resources Engineering
(retired May, 1982)

* Member of the Finance Committee ** Member of the Research Program Advisory Committee

The Board of Governors and Special Guests, March 1982, with the President and other members of the University. Seated, from left: Dr. R. F. Shaw; Dr. A. A. Bruneau; Dr. L. Harris, President, Memorial University; Mr. E. F. Hewlett; Dr. I. E. Rusted, Vice-President, Professional Schools and Community Services; Mr. S. T. Mathews. Standing, from left. Dr. R. Pottie; Mr. V. L. Young; Mr. D. M. Grenville; Mr. H. Lundrigan; Prof. C. D. diCenzo; Mr. H. L. Snyder; Mr. G. R. Harrison; Dr. W. L. Ford; Dr. E. R. W. Neale, Vice-President, Academic; Mr. G. N. Ewing; Mr. G. B. Woodland, Director, University Relations; Mr. W. W. Thistle, Vice-President, Administration; Mr. G. Derbowka; Mr. H. M. Clarke; Mr. F. D. Smith.

Report of the Director and Board of Governors

Introduction

This is the seventh Annual Report of the Centre for Cold Ocean Resources Engineering covering the period from April 1, 1981 to March 31, 1982.

At the outset of the year under review, as reported in the 1980/81 Annual Report, C-CORE was well settled into its new quarters in the Captain Robert A. Bartlett Building which had just been formally opened and handed over to the University. The establishment of C-CORE in its own building has given coherence to its operations and a heightened visibility which has enabled it to function fully as a Centre. This has manifested itself in a number of ways: closer relations with faculty (two engineering professors from Memorial are currently working in the building during their sabbatical leave); attendance by members of the local and university community at meetings and seminars held in the building; a continued stream of visitors throughout the year.

Ocean Engineering Information Centre

The Ocean Engineering Information Centre (OEIC) has flourished for the same reasons. its accessibility and higher profile have led to an increase in the number of users from the local ocean engineering community outside the University. At the conclusion of the year under review, the OEIC was awarded a contract by the National Research Council's Canadian Institute for Scientific and Technical Information (CISTI) to provide certain information services during the period leading up to the start of operations by NRC's Arctic Vessel and Marine Research Institute, now under construction on Memorial's campus.

The Research Program

The graphic illustration 'C-CORE Programs: Past, Present and Proposed' on page 1 shows the evolution of research programs since the Centre's inception, the level of expenditures required to support these operations and the apportionment to the main research areas: sea ice engineering, radar, seabed engineering and oil-in-ice.

Sea Ice Engineering: The Ice Engineering Group's objective is to gather and make accessible to engineers the sea ice data that are required for the design of systems and structures for ice-frequented oceans. During the year, the group was reorganized under Dr. Ernie Reimer, several of C-CORE's original Sea Ice Group having moved into INSTRUMAR or other industrial opportunities.

The initial program of the group is focused on the investigation and measurement of ice conditions, stresses, strengths, and the energy transfer from turbulent seas. A field program to test some initial ideas for the rapid measurement of the engineering properties of sea ice was mounted in February 1982 at Pond Inlet, on Baffin Island, and another series of experiments were undertaken in the Strait of Belle Isle during May. The group is assessing both acoustic and electrical techniques for bulk measurement systems.

Radar: The Airborne Impulse Radar Unit developed by C-CORE was sold to INSTRUMAR, which is continuing the development of this system. During the year, the two programs in high frequency radar ocean sensing continued. With funding from Fisheries and Oceans Canada, C-CORE acquired a single site CODAR (Coastal Ocean Dynamics Applications Radar) surface

Special Guests to the Board of Governors' Meetings

Mr. W. E. Barratt
Corporate Manager
Imperial Oil Limited

Dr. A. E. Collin
Associate Deputy Minister
Energy, Mines & Resources Canada

Mr. G. Derbowka
Director of Research and Development
Petro-Canada

Dr. W. L. Ford
Consultant

Dr. M. J. Keen
Director
Atlantic Geoscience Centre

Dr. A. Longhurst
Director-General
Bedford Institute of Oceanography

Dr. R. Pottie
Atlantic Regional Director
National Research Council of Canada

The Rt. Hon. Lord Shackleton, KG, PC, OBE
Deputy Chairman
Rio Tinto-Zinc Corporation

Mr. F. D. Smith
President
NORDCO Limited

Mr. V. L. Young
Chairman
Newfoundland & Labrador Hydro

During the year, C-CORE reformed its Ice Engineering Group to focus efforts on measurement of ice properties and forces. The group mounted a field trip to Pond Inlet, N.W.T., in February to make some first tests of new ideas for solutions to these problems.

current mapping system. This was successfully tested off Cappahayden, south of St. John's. Testing of HF signal propagation over sea ice was begun in March, using the CODAR equipment, as a preliminary investigation of HF radar capability for ice hazard detection. Meanwhile, we are proposing to achieve a full two-site capability for surface currents by summer 1983, and to host an international conference on HF radar sea state measurement in the fall of that year.

The program to establish the feasibility of operational surveillance of surface winds over the east coast using HF sky wave radar is presently nearing completion. Results have been quite encouraging; a report on the program with recommendations for future directions will be completed later in this year.

The enhancement of the information display from standard marine radar equipment through interpretation of background "noise" has been successfully demonstrated through initial testing over open water at Cape Spear, near St. John's, and a first look at sea ice returns was recently taken at Cape Norman, on the Great Northern Peninsula. This work is of considerable interest to the Canadian Coast Guard and the Arctic oil exploration industry as well as shipping companies. In May, the system was taken to the Tarsuit artificial island in the Beaufort Sea to monitor the ice movement for Gulf Canada Resources Limited.

Seabed Engineering: In the early part of the year under review, the activities of the Seabed Group continued to be concentrated on the Grand Banks in the Hibernia area. However, as the geological mapping and seafloor characterization of this area approached completion, opportunities arose for extending the ice scour and sediment dynamics research. In October, dives were carried out on the central Labrador Banks and in the Strait of Belle Isle in the manned submersible *Pisces IV*, which permitted firsthand visual examination and material sampling. Both iceberg scours and the dynamics of the sediments in the region were investigated. At the same time, members of the group aboard *CSS Hudson* were collecting acoustic geophysical data and seabed cores and samples in the vicinity of the Hekja wellsite off Southeast Baffin Island. These data sets form the basis for an examination of iceberg scouring and sediment stability in this deep water by determining past sea level fluctuations and present dynamics.

The prototype seabed corer developed by the Centre went through sea trials during the year, followed by a series of laboratory tests. Although the concept of a remotely operated seafloor platform worked, difficulties were encountered in the control mechanisms to secure undisturbed seabed samples. Further development and sea testing of the corer is continuing.

At the end of the year, the Seabed Group had its first opportunity to collect data, in conjunction with the Atlantic Geoscience Centre, in the dynamic Sable Island exploration area off Nova Scotia. C-CORE's seabed research now encompasses all the active oil exploration areas on Canada s east coast.

Oil in Ice: C-CORE has been involved in the national program to investigate the suitability of chemical dispersants for Arctic waters. Results indicated that toxicity effects on sea life were much lower in the field than in laboratory tests, and that barring containment and recovery, natural degradation would overall be less harmful.

A laboratory program was carried out using the

facilities of the Faculty of Engineering to test some concepts of subsea containment of a well blowout. These were encouraging and a direction for full-scale field testing was brought forward. The development of an absorbing/sinking agent, with the concept of incorporating oil-degrading bacteria, was completed.

It was decided during the year that the oil-in-ice program should be wound down, and that the efforts of the personnel involved should be refocused onto the ice engineering program.

Research Plan

The outline plan, which appears on page 10 of this report, presents the current set of objectives towards which the Centre is working. These continue to evolve from the process of consultation and review that is carried out regularly by the research staff with the Centre's Associates, this Board, and the community at large.

INSTRUMAR Limited

It was noted in the 1980/81 annual report that the process of separating INSTRUMAR Limited had been implemented. On September 15, 1981 ownership of INSTRUMAR was transferred from Memorial University to the nine-member employee group that undertook to launch the Company. Alastair Allan is President and Kenneth Butt is Vice-President. INSTRUMAR is now an independent commercial venture, and is establishing a solid base for its future growth.

The separation agreement provided for the lease of space and the use of support facilities in the Bartlett Building. This has preserved the close working relationship between the two groups through the transition period. INSTRUMAR plans to move to new premises by the fall of 1982, possibly as the first step in establishing a government assisted "high-technology" industrial park in St. John's.

INSTRUMAR will continue to provide C-CORE with a number of essential manufacturing and technical services and to participate in various joint projects on a contractual basis.

Funding

The Centre's Associates have continued to honour their funding pledges during the past year in spite of the economic downturn. The problems have not abated and it is possible that they may intensify in the 1982/83 fiscal year. Accordingly, efforts to expand the base of C-CORE's financial support are continuing.

Financial

C-CORE's operating account position for the year under review is presented in the current report in the accompanying Balance Sheet and Statement of Revenue, Expenditure and Surplus, all of which have been prepared on an accrual basis. The C-CORE Research Trust which stood at $1,345,698 at the beginning of the year under review, received contributions during the year of $988,000 and interest was credited to it of $184,202 for the period. The release and transfer from the Trust to operating account of $1,300,000 was authorized to cover the Centre's core operating expenditures. A further $285,519 was received from contracts, contributions to programs and other sources and credited to operating account, resulting in total revenue for the year of $1,585,519. Expenditures for the year were $1,550,545, resulting in an excess of revenue over expenditure for the year of $34,974 and a conversion of the deficit carried forward at the beginning of the year to a surplus of $54,617 at the year end.

In addition to cash grants, contract revenue and other receipts, C-CORE also received in 1981/82 support-in-kind to an estimated total value of $455,000 in the form of field services and logistic support from government agencies and industry, and of accomodation, facilities, services and equipment provided by Memorial University.

For the 1982/83 fiscal year, the Centre has budgeted capital and operating expenditures and income from all sources of $1,650,000. The Board of Governors has authorized the release from the Research Trust of up to $1,200,000 to cover core operating expenditures during the year.

Current revenue forecasts indicate that contributions into the C-CORE Research Trust and interest in 1982/83 may be approximately equivalent to the probable drawdown from the Trust.

Board of Governors

Dr. R. F. Shaw, who has served as Chairman of the Research Program Advisory Committee for the past two years, retired from the Board following its March, 1982 meeting. He was the last member of the original Board of Advisors which was formed at the Centre's inception in 1975. The other members of the original Board were Dr. A. E. Pallister, its Chairman, and Dr. O. M. Solandt, who retired the previous year in 1981, and Mr. A. R. Nielsen who retired in 1980. The Centre owes a deep debt of gratitude to each of these distinguished Canadians who gave unstintingly of their skills, enthusiasm and time to lay the firm foundation on which C-CORE has continued to grow.

Other members of the Board who retired during the year under review were Dr. W. Denner, Mr. A. Janisch, Mr. D. G. Little and Mr. S. T. Mathews. Their counsel and participation in C-CORE's affairs is greatly appreciated.

Mr. D. M. Grenville, who has been Secretary of this Board and Administrator of C-CORE since 1975, has left the Centre to join the Royal Commission on the "Ocean Ranger" Marine Disaster. Ms. Judith Whittick has taken over as Administrator, while continuing to be responsible for the operation of the Ocean Engineering Information Centre.

A. A. Bruneau
Chairman

H. L. Snyder
Director

Associates of C-CORE

B. P. Canada Ltd.
Canadian Superior Oil Ltd.
Canterra Energy Limited
Dome Petroleum Limited
Esso Resources Canada Limited
Gulf Canada Resources Inc.
Hudson's Bay Oil & Gas Company Limited
Mobil Oil Canada, Ltd.
NORCEN Energy Resources Limited
PanCanadian Petroleum Limited
Petro-Canada
Polar Gas Project
Shell Canada Resources Limited
Texaco Canada Resources Ltd.

Albery, Pullerits, Dickson & Associates
Bechtel Canada Limited
Brown & Root Ltd.
CanOcean Resources Ltd.
CN Marine
Fenco (Nfld.) Limited
Golder Associates
Huntec ('70) Ltd.
INSTRUMAR Limited
NORDCO Limited
Remotec Applications Inc.
Royal Bank of Canada
ShawMont Newfoundland Ltd.
Woodward-Clyde Consultants

Representatives of some of C-CORE's Associates in Memorial Engineering's Structures Laboratory during the three-day Associates' Workshop held in October. In right foreground is John Murray, Project Engineer, Ocean Engineering Group, who conducted the tour of the facilities.

The Research Group

Harold Snyder	Director
William Winsor	Assistant Director
Judith Whittick	Administrator; Head, OEIC
Vaughn Barrie	Leader, Seabed Group
Ken Butt*	Leader, Radar Group
Ernie Reimer	Leader, Ice Engineering Group
David Bazeley	Leader, Publications Group
Sherilyn Beaton	Projects Controller
Mary Booton	Administration
Denny Christian	Instrumentation
William Collins	Seabed Processes
Deborah Diemand	Ice Properties Measurement
Gary Gidney	Computer Systems & Data Processing
Ken Hickey	Radar Data Processing
Phil Jeans	Ice Radar Engineering
Ken Klein	Ice Radar Development
Bruce Parsons	Ice Forces & Interactions
Chris Pereira	Seabed Geology
A. Pushpanathan	Engineering Systems
Randy Raymond	Computer Signal Processing
Chantal Roche	Radar Data Coordination
Barbara Rodden	Information, Data Bank
Alvin Simms	Statistical Analysis and Programming
Chris Woodworth-Lynas	Iceberg Scour Analysis
Eric Woolgar	Ice Properties Measurement

* seconded from INSTRUMAR Limited

Support Staff Group:

Cavell Kavanagh
Rosalie Murphy
Linda Davis
Sheila Hearn
Norma Matthews

Research Group Members who have left the Centre to take up new positions:

David Grenville
John Jones
K. S. Chang
Susan Waterhouse
Terry Ridings
Tom Laidley
Gerald Goobie
Gordon Swaters

Another 35 individuals joined the research and support groups for part of the year from many sectors of the engineering and scientific community. These included secondments from industry, sabbatical arrangements with academic faculty, and student assistants from engineering and other subject areas.

Two new C-CORE Fellowships for graduate students in Ocean Engineering were awarded during the year, to Roy Dawe, ("Geotechnical Investigation of Seabed Stability off Canada's East Coast") and to John Murray ("The Effect of Ocean Wave Groups on Floating Structures"). The Fellowship awarded last year to Joseph Ryan ("The Scattering of Electromagnetic Energy from a Vertical Discontinuity; Operator Expansion Approach") was renewed for a second year.

The Research Plan — 1982/83

Introduction

The goals of the Centre's technical program are frequently reviewed and assessed by the staff with the Research Program Advisory Committee of the Board of Governors and with industry representatives of the Associates of C-CORE. The objective of these reviews is to ensure that the Centre's resources are most productively deployed in response to emerging needs and anticipated developments. In the following sections, plans for the next five years are presented in relation to forecast development needs.

In order to design systems and structures that are reliable and safe yet economic, and which result in the minimum of environmental disturbance, engineers require both detailed site descriptions and the magnitudes of the loads likely to be experienced during construction and subsequent operation. There are knowledge gaps important to frontier engineering and development which must be bridged before large scale projects can proceed. C-CORE's research effort is and will continue to be directed to bridging certain of these gaps.

Sea Ice Engineering

Refinement of the engineering design of structures and systems in ice frequented oceans requires a better understanding of sea ice as a material, as well as the development of new engineering techniques. These requirements remain central to C-CORE's purpose.

Sea Ice Forces: Projects directed toward improving the measurement and understanding of the physical properties and processes in natural ice covers will continue as a basic component of C-CORE's ice engineering research. The research group will direct a substantial effort into the development of new techniques and instrumentation systems for the field measurement of ice forces. The ability to interpret the level of stress developed in pack ice will provide access to the design tool of stress analysis.

Dynamic Interactions: The dynamic characteristics of sea ice environments and the behaviour of both ice and structures during impact or penetration are both critical aspects of reliable engineering design for ice resistant structures. An investigation of energy dissipation processes during ice/structure interaction has been initiated. There is a need for a designer's guide to site specific ice conditions and dynamics which would include some qualitative index for both average conditions and extreme events. An assessment of important variables (e.g. ice thickness, strength, salinity, temperature, homogeneity, snow cover, wind, waves, fetch, currents, tides, motion, etc.) with respect to geography is underway. The key element in preparing such a "Sea Ice Environments Source Book" will be the establishment of either a combined index of the above variables or a classification scheme which alerts a designer to the critical factors in a given geographic region.

Tactical Ice Management: The addition of tactical ice management techniques as a strategic design component may enhance the reliability of passive offshore structures and the facilitation of shipping in the Arctic. We are investigating the efficiency and reliability of explosives and other techniques that may be used.

Remote Identification and Monitoring

There is an ongoing need for environmental information both at the system design phase and during system operation. Such environmental data is required as a basis for the climatic forecasts used in planning, the monitoring of hazards and the prediction of critical events. There are a number of events offshore where a better remote sensing capability could support more reliable design and safer, more efficient operations. Among the hazards encountered in northern offshore waters are pack ice, large floes including multi-year ice, ice ridges, icebergs and iceberg fragments. These are in addition to the hazards generally associated with the ocean: waves, storms, pollution accidents, moving vessels and mobile structures. The combination of the ice and ocean regimes in the marginal ice zone requires special attention. HF radar appears to hold considerable promise for remote sensing in these regimes and the Centre will continue to focus on its development as an operational tool.

Remote Measurement by HF Radar: High frequency (HF) Doppler radar can be applied to measure and map a number of ocean parameters such as wave directions and surface current velocities. Frontline research in this field is now directed at measuring the wave height spectrum and thus quantifying sea state.

New developments in antenna design and signal processing enabled development of a ground wave HF radar system called CODAR (Coastal Oceans Dynamics Applications Radar), which can measure ocean variables at ranges of about 60 km, from self contained portable facilities. C-CORE acquired a CODAR system during 1982, and we shall be investigating whether it is feasible to compensate for antenna motion that would enable operation from vessels, buoys or offshore platforms. This advance would permit surveillance beyond the range of the present shore based stations.

Iceberg Dynamics: The input of real time data will continue to be vital to any operational ice management system. A spatial description of surface currents would assist in the prediction of an iceberg's motion. The ground wave HF radar can provide a map of the surface currents in real time, and thus, together with other sources, may provide a practical prediction system.

Surface Drift Prediction: The ground wave HF radar has potential application for real-time modelling, of great importance for search and rescue, and for oilspill tracking. It could beneficially replace the various models and simulations on which government and industry currently rely. The associated capability for transponder tracking by an HF system would provide additional information on slick transport and other applications in which displacements and speeds need to be monitored.

Seabed Engineering

Seabed Processes: The surveys and research to date have shown that the continental shelves of eastern Canada have a number of unique features. To understand how these features will affect engineering for the offshore and what mitigating actions may be necessary, will continue to be a focus of the Centre's research in this area.

Seabed Geology: All of the studies directed to understanding the seabed environment must grow from an understanding of the fundamental seabed geology. Over much of the east coast offshore region, our greatest need remains a portable corer and associated test equipment to allow the *in situ* measurement of the mechanical properties of seabed sediments quickly and economically. The usual oceanographic samplers are unable to penetrate the tough sediments we have generally encountered during our field work. The present technology for obtaining such data is to use dedicated ships which are capable of detailed site investigations, but are very costly. The Centre will continue to map the seafloor using acoustic geophysical technology, to identify the sources of the sedimentary materials, relic coastal zones, and to classify minerals and their distributions.

Iceberg Scouring: A major focus of the program at the Centre is to quantify the frequency of occurrence of iceberg scouring, an important phenomenon which continues to occur. The risk of having a grounding iceberg strike a seabed installation and the magnitude of the forces involved are important concerns. C-CORE will continue to address these concerns through a variety of techniques, and through collaborative programs with other organizations.

Sediment Dynamics: C-CORE is in the preliminary stages of quantifying the dynamics of the east coast seabed sediments. It has already been established that the regime is extremely dynamic and that sediment transport is a continual process. The currents that create the conditions observed, present a whole new set of engineering problems for which solutions are needed. Seabed surface installations may be undercut or buried and installations which have been deliberately buried for protection may be exposed. Seabed excavations during construction may be subject to rates of infilling which may prove a problem and are yet to be calculated.

Continental Slope: There is a requirement to develop techniques and equipment that will provide a description of the seabed on the continental slopes in support of the move of the offshore industry towards exploration in the deeper water on the slopes. At present, there is very little knowledge about either the surficial geology or the dynamic processes of materials on Canada's continental slopes.

Construction of the Arctic Vessel and Marine Research Institute for the National Research Council of Canada began during the summer of 1981. The site for the Institute is on Memorial University's campus, adjacent to the S. J. Carew Building (Engineering and Earth Sciences) and to the Captain Robert A. Bartlett Building (C-CORE and OEIC). The first phase, the research offices, is scheduled for completion early in 1983. The other phases, including the 80m vessel testing basin with natural saline ice and the 200m open water testing basin, will follow immediately.

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
BALANCE SHEET AS AT 31 MARCH 1982

	1982	1981
Assets		
Research trust (Note 4)	$1,217,900	$1,345,698
Accounts receivable	161,084	193,667
Prepaid expense	8,774	—
	1,387,758	1,539,365
Fixed assets - at cost		
Bartlett Building (Note 3)	1,038,841	1,038,841
Equipment	468,820	292,457
Less: Accumulated depreciation	270,637	169,936
	198,183	122,521
	1,237,024	1,161,362
Total assets	$2,624,782	$2,700,727
Liabilities and Surplus		
Accounts payable and accrued liabilities	$ 62,944	$ 22,253
Interest-free advance from Memorial University of Newfoundland with no specific terms of repayment	279,858	274,292
Total liabilities	342,802	296,545
Equity		
Equity in research trust	1,217,900	1,345,698
Equity in building	1,038,841	1,038,841
Surplus	25,239	19,643
Total equity	2,281,980	2,404,182
Total liabilities and equity	$2,624,782	$2,700,727

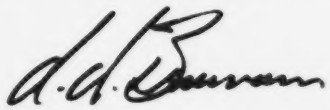
See accompanying notes.

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
STATEMENT OF REVENUE, EXPENDITURE AND SURPLUS
FOR THE YEAR ENDED 31 MARCH 1982

	1982	1981
Revenue		
Research trust	$1,300,000	$1,200,000
Research contracts	242,497	227,194
Other	43,022	76,361
Total revenue	1,585,519	1,503,555
Expenditure		
Staff salaries	830,494	717,525
Research programs	485,320	347,982
Support services	114,516	97,448
Ocean Engineering Information Centre	85,102	79,414
Fellowships	17,000	58,154
Board of Governors	47,491	44,775
Total expenditure	1,579,923	1,345,298
Excess of revenue over expenditure	5,596	158,257
Surplus (deficit), beginning of year	19,643	(138,614)
Surplus, end of year	$ 25,239	$ 19,643

See accompanying notes

Signed on behalf of Memorial University of Newfoundland



Chairman, Board of Governors

Comptroller, Memorial University of Newfoundland

Accounting Policies

(a) The Research Trust is shown on a cash basis.
(b) Depreciation is calculated on a straight line basis as follows:

Equipment	5 years
Tools and marine equipment	2 years
Computer software and other equipment	1 year

No depreciation is recorded on the Bartlett Building.

2. Relation to Memorial University of Newfoundland

The Centre for Cold Ocean Resources Engineering (C-CORE) is a self-reliant organization of Memorial University, which is owner of C-CORE's building and equipment and beneficiary of its assets and liabilities. In the event that C-CORE is terminated, facilities and equipment provided or acquired for C-CORE shall remain the absolute property of the University.

As such, these financial statement figures represent a segment of the activities of Memorial University of Newfoundland and are included in the audited financial statements of the University for the year ended 31 March 1982.

3. Bartlett Building

In order to properly reflect the entire operations of C-CORE as a separate entity, the Bartlett Building, which is owned by Memorial University of Newfoundland but of which C-CORE has exclusive use, has been included in the financial statements for 1982 and 1981 at a cost of $1,038,841.

4. Funds in Research Trust

All the incoming funds which are designated as contributions to C-CORE's research programs are deposited for credit to the C-CORE Research Trust. The Comptroller of Memorial University of Newfoundland administers the C-CORE Research Trust on behalf of the Trustee, the Board of Regents of Memorial University.

Cash transactions in the Research Trust during the year were as follows:

Balance in bank, 1 April 1981	$1,345,698
Receipts:	
Industry	788,000
Government of Canada	200,000
Investment income	184,202
	1,172,202
Less: Transferred to the Centre's Operations	1,300,000
Net contribution during the year	(127,798)
Balance in bank, 31 March 1982	$1,217,900

5. Support-in-kind

Management has estimated the cost of various services provided without charge by Memorial University of Newfoundland, the Province of Newfoundland and other agencies at $455,000 for the year ended 31 March 1982 ($461,159 -1981).

6. Comparative figures

Certain of the 1981 financial statement figures have been reclassified to conform with the current year's presentation.

DEPARTMENT OF THE AUDITOR GENERAL
ST. JOHN'S, NEWFOUNDLAND

AUDITOR'S REPORT

The Board of Regents
Memorial University of Newfoundland
St. John's, Newfoundland

I have examined the balance sheet of the Centre for Cold Ocean Resources Engineering as at 31 March 1982 and the statement of revenue, expenditure and surplus for the year then ended. My examination was made in accordance with generally accepted auditing standards, and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Centre as at 31 March 1982 and the results of its operations for the year then ended in accordance with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

J. F. McGrath, C.A.

J. F. McGrath, C.A.
Auditor General

St. John's, Newfoundland
22 July 1982

Reports and Publications for 1981

81-1 Winsor, W. D., Jackman, M. and Power, G. "Cruise Report Ice Feature Observations from the *CCGS Franklin*, Summer 1979." Data Report, 107 pp., February 1981.

81-2 Ball, P., Gaskill, H. S. and Lopez, R. J. "Iceberg Motion: An Analysis of Two Data Sets Collected at Drill Sites in the Labrador Sea." Technical Report, 121 pp., April 1981.

81-3 Goobie, G. I., Laidley, T. E. and Reimer, E. M. "C-CORE Oilspill Research". In Proceedings of AMOP Conference, Edmonton, June 16-18, 1981.

81-4 Reimer, E. M. (ed) "Subsurface Oil Movement off the Newfoundland South Coast During 1979." Data Report, 98 pp., April 1981.

81-5 Butt, K. A. and Reimer, E. M. "Presentation of an HF Radar Development Program to the Eastern and Arctic Petroleum Operators Associations." 28 pp., May 1981.

81-6 Allan, A. J. and Bazeley, D. P. (eds) "Test Platforms for the Measurement of Ice Forces." Technical Report, 220 pp., May 1981.

81-7 Reimer, E. M. "Nearshore Surface Current Delineation, Cape Hatt, 1980." Data Report, 29 pp., May 1981.

81-8 Lewis, C. F. M. and Barrie, J. V. "Geological Evidence of Iceberg Groundings and Related Seafloor Processes in the Hibernia Discovery Area of Grand Bank, Newfoundland." In Proceedings of the Symposium on Production and Transportation Systems for the Hibernia Discovery, St. John's, February 17-19, 1981.

81-9 Ball, P., Gaskill, H. S. and Lopez, R. J. "Environmental Data Requirements for a Real Time Iceberg Motion Model." In Proceedings of the 6th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC 81) Quebec City, July 27-31, 1981, Vol. III.

81-10 "Subsea Containment." Contract Report for Dome Petroleum Ltd. 65 pp., August 1981.

81-11 "*MV Arctic* Lake Melville Probe 1981. Airborne Impulse Radar: Uses and Limitations as an Ice Navigation Aid on Lake Melville." Contract Report for Melville Shipping Ltd. 14 pp., August 1981.

81-12 "C-CORE Annual Report 1980-81." 16 pp., October 1981.

81-13 Barrie, J. V. and Snyder, H. L. "Seabed Investigations of the Canadian Atlantic Continental Shelf." Presented to the Canadian Petroleum Association Colloquium III: Petroleum Mapping and Surveys in the 80's, Banff, Alberta, October 14-16, 1981, 16 pp.

81-14 Butt, K. A. and Jeans, P. K. "H. F. Radar Technology Transfer Project - Evaluation Phase." Technical Report, 136 pp., October 1981.

81-15 Snyder, H. L. and Grenville, D. M. "Engineering Research in the Cold Ocean Environment." Presented to the Canadian Research Management Association Annual Meeting, Halifax, Nova Scotia, November 19, 1981, 9 pp.

81-16 "Electrochemical Anemometer Development Summary Report, October 1981." Contract Report, 28 pp. This report is proprietary to INSTRUMAR Ltd., St. John's, Nfld.

81-17 Snellen, J. B. and Rossiter, J. R. "Remote Estimation of Sea Ice Properties: Surface Truth Measurements, Beaufort Sea, March 1979." Technical Report, 114 pp., December 1981.

81-18 Amos, C. L., Asprey, K. W. and Rodgers, N. A. "Bedford Institute Sedimentation Tube-B.I.S.T." Bedford Institute of Oceanography Report Series BI-R-81-14, September 1981, 60 pp.

Reports and Publications for 1982 (to July)

82-1 Josenhans, H. W. and Barrie, J. V. "Preliminary Results of Submersible Observations on the Labrador Shelf." Geological Survey of Canada Current Research, Part B, Paper 82-1B, pp. 269-276.

82-2 Barrie, J. V., Pereira, C. P. G. and Woodworth-Lynas, C. M. T. "Data Report of the Hekja Wellsite Marine Survey, *Hudson* Cruise 81-045." Data Report, 50 pp., May 1982.

82-3 Diemand, D., Reimer, E. M. and Barrie, J. V. "Ocean Drifter Studies of Surface Currents along the Coasts of Newfoundland and Labrador and in the Beaufort Sea." Technical Report, 60 pp. May 1982.

82-4 Barrie, J. V., Lewis, C. F. M., Fader, G. B., King, L. H. and Amos, C. L. "Seabed Processes on the Northeastern Grand Banks, Modern Reworking of Relict Sediments." Abstract accepted for the Eleventh International Congress on Sedimentology, McMaster University, Hamilton, Ontario, August 22-27, 1982.

82-5 Woolgar, E. G., and Reimer, E. M., "Comments on a Technique to Measure Mixing Energy Available for Oilspill Dispersion." In Proceedings of the 5th Arctic Marine Oilspill Program Technical Seminar, Edmonton, Alberta, June 15-17, 1982, pp. 25-36.

82-6 Josenhans, H. W. and Barrie, J. V. "The effect of icebergs on the Labrador Shelf as seen by submersible *Pisces IV*." Geological Survey of Canada Open File 843, 3/4 inch colour videotape, 18 minutes.

'Technical Reports', 'Data Reports', 'Conference Proceedings' and Information Publications are normally available from C-CORE. The availability of 'Contract Reports' is noted individually. Preprints of papers presented by C-CORE members to external meetings or submitted to other publications are available from C-CORE, unless timely external publication is expected.

Information Publications

82-A "C-CORE News Volume 7, No. 1" 8 pp., February, 1982.

82-B Bazeley, D. P. "C-CORE, Ice and Engineering Research." Dialogue for Engineers (APEN) St. John's, May 15, 1982, pp. 1-3.

82-C "C-CORE News Volume 7, No. 2" 8 pp., June 1982.

82-D "C-CORE Annual Report 1981-82" 16 pp., August, 1982.

OCEAN NEWTECH: a two-day exhibition of ocean related technological innovation in Newfoundland and Labrador was held in St. John's in March. Chairman of the exhibition for the Marine Technology Society was David Grenville of C-CORE, and several other members of the Centre were closely involved in organizing the event. Twenty-four local companies and institutions, including C-CORE, OEIC, REMOTEC Applications Inc., INSTRUMAR Limited and Memorial Engineering's Ocean Engineering Group, exhibited their products and services. (Photo: Bill White, ETV)

Number/
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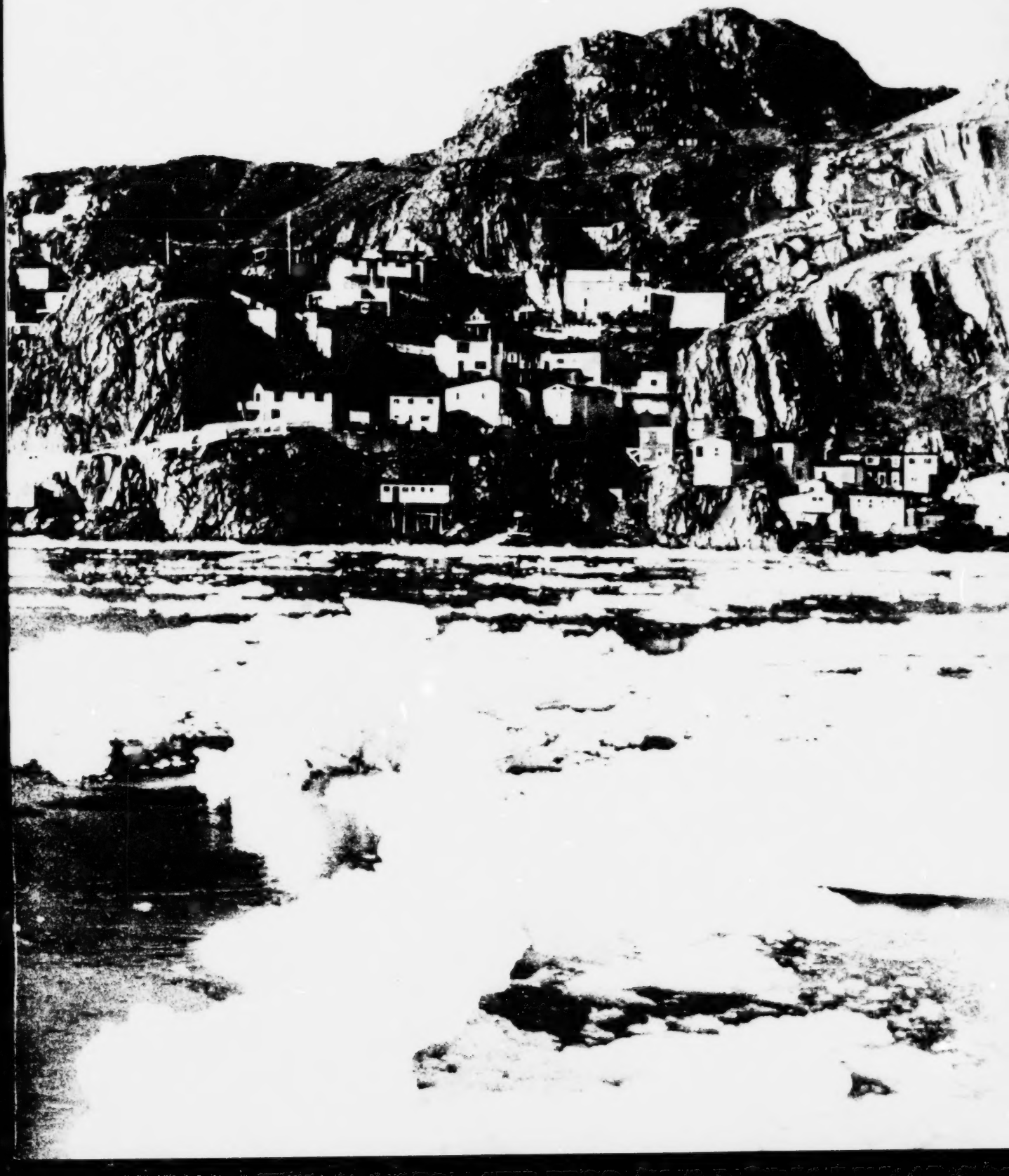
C-CORE Annual Report 1982-83



C-CORE Field Programs 1982 — 1983

April 1982		
	Cape Norman Newfoundland	Ice observation with radar enhancement system
	Sable Island Nova Scotia	Geophysical surveys and sediment dynamics
May		
	Tarsiut Island Beaufort Sea	Ice movement using radar enhancement system
	Strait of Belle Isle Newfoundland	Ice identification and properties
August		
	Norploy '82 Labrador Sea Hamilton Bank	Iceberg scours using a submersible. Measurement of iceberg temperatures.
September		
	CSS Hudson Davis Strait Baffin Bay	Subsurface geology of the Continental Shelf
October		
	Conception Bay Newfoundland	CODAR field trials
	CSS Hudson Labrador Sea	Seabed investigations
	Northern Bay Sands Newfoundland	HF Radar Oceanographic experiment
November		
	Adam's Island N. W. T.	Ice forces study
	Pond Inlet N. W. T.	First year ice sheet study
	Tarsiut Island Beaufort Sea	Ice properties measurement
	Placentia Bay and off St. Mary's, Newfoundland	Seabed corer field test
February 1983		
	Cappahayden & Cape Race Newfoundland	CODAR 2 site field trial
	Tarsiut Island Beaufort Sea	Ice properties measurement
	Pond Inlet N. W. T.	First year ice sheet study
March		
	Adam's Island N. W. T.	Ice forces study

COVER PHOTO:
Winter 1983 in St. John's Harbour. The Battery is seen in the background.

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BEAUFORT SEA
Tarsiut
Adams Island
BAFFIN BAY
DAVIS STRAIT
LABRADOR SEA
Northern Bay Sands
CONCEPTION BAY
St. John's
LABRADOR
Hamilton Bank
STRAIT OF BELLE ISLE
Avalon Peninsula
PLACENTIA BAY
Cappahayden
St. Mary's
Cape Race
NEWFOUNDLAND
St. John's
GRAND BANKS
Sable Island

The Board of Governors and Special Guests, on the occasion of their meeting in Calgary, March 1983.
Back Row L-R Mr. W. D. Winsor, Dr. A. E. Collin, Dr. A. A. Bruneau, Mr. V. C. Larson, Mr. A. Jones.
Second Row L-R Mr. H. Lundrigan, Dr. A. E. Pallister, Mr. H. L. Snyder, Dr. R. Pottie, Mr. R. Y. Pogontcheff.
Front Row L-R Mr. D. R. Motyka, Mr. G. N. Ewing, Dr. G. R. Peters, Ms. J. A. Whittick, Ms. S. J. Beaton, Dr. M. E. Hriskevich.
Photo: Matthews Photo Lab Ltd.

Special Guests to the Board of Governors' Meetings

Churchill Falls, September, 1982

Mr. L. V. Brandon
Director General, Engineering Control Branch
COGLA
Energy, Mines & Resources Canada

Mr. G. Derbowka
Director, Research and Development
Petro Canada

Dr. W. L. Ford
Consultant

Mr. W. Lawton
Senior Engineer
Rio Tinto Zinc Corporation

Mr. S. Millan
Executive Director
Petroleum Directorate
Government of Newfoundland and Labrador

Mr. J. Sneed
Producing Manager East
Mobil Oil Canada Ltd.

Mr. W. A. Talley, Jr.
President
Can Ocean Resources Ltd.

Dr. W. F. Weeks
Researcher
U. S. Army Cold Regions Research & Engineering Laboratory

Calgary, March, 1983

Mr. M. E. Hriskevich
Senior Vice President
Canterra Energy Ltd.

Mr. A. Jones
Executive Vice President
Canadian Marine Drilling Ltd.

Mr. V. C. Larson
Manager, Research
Esso Resources Canada Ltd.

Mr. D.R. Motyka
Vice President, Frontier
Gulf Canada Resources Inc.

Dr. A. E. Pallister
President
Pallister Resource Management Ltd.

Mr. R. Y. Pogontcheff
Senior Vice President
Husky Oil Ltd.

Report of the Director and Board of Governors

Introduction

This is C-CORE's eighth Annual Report covering the period from April 1, 1982 to March 31, 1983.

It has been a very active year. Field programs originally concentrated in the winter months are now undertaken on a year-round basis in the East Coast Offshore and in the Arctic. The heavy ice conditions experienced off St. John's in the winter of 1983 gave the researchers an excellent opportunity to study the pack ice and icebergs "on the door step".

Many individuals and groups visited the Centre, learned about its programs and gained an appreciation of the importance of the growing ocean engineering community in St. John's. INSTRUMAR Ltd. has moved from the Captain Robert A. Bartlett building into the office building of the National Research Council's Arctic Vessel and Marine Research Institute (AVMRI). INSTRUMAR Ltd. will continue to interact closely with the academic research community. Discussions with the National Research Council on the level of cooperation between the AVMRI facility and C-CORE continue. The AVMRI will make an international contribution to the design and development of vessels and structures in Arctic waters and it is anticipated that the Centre's field experience and programs will provide important support for the new laboratory facilities.

Two engineering professors joined C-CORE on their research semesters to participate in Seabed and Ice Properties projects. A number of engineering co-op students undertook ocean-related projects supported by C-CORE under the supervision of members of the Faculty of Engineering and Applied Science. C-CORE hosted a number of seminars and workshops throughout the year and these were well attended particularly by scientists and engineers from outside the province. The research staff also presented lectures for the University's Continuing Engineering Education programs.

The Research Programs 1982/83

The three areas of research are Radar and Remote Sensing, Seabed and Ice Properties. The Oil in Ice program was wound down over the year and increasing emphasis was placed on the Ice Properties program.

Radar and Remote Sensing Program

The HF technology transfer program, supported by the Department of Fisheries and Oceans, was completed with a two station CODAR field project to map the surface circulation over the Ballard Bank at the southeast tip of the Avalon Peninsula, Newfoundland. The radar sites were established at Cappahayden and Cape Race. A further dimension was added to the fieldwork by intermittent pack ice cover south to Cape Race and beyond during the experimental period.

The Centre had an HF wide aperture narrow beam antenna constructed for its HF radar development system. This antenna will serve as an integral component in testing the radar for the detection of sea ice and icebergs. The antenna was field tested at Northern Bay Sands, Conception Bay, Newfoundland, under a contract to Department of Fisheries and Oceans. This was part of the application of funding from the Office of Energy Research and Development (Energy, Mines and Resources) to foster new ocean technologies in support of frontier and ocean energy projects.

The data processing and analysis phase of the skywave over-the-horizon HF radar experiment was completed. The results were encouraging; the ocean Doppler spectrum was evident in the radar backscatter. A decision on the continuation of the program will be made when the report, which is now in preparation, is finished.

There was further fieldwork and collection of data on ice imagery with the marine radar units utilizing our grey (multi) level display at the Tarsiut site in the Beaufort Sea in May, 1982. A number of other picture processing ideas were explored on Remotec Applications Ltd.'s Image Analyzer. We had planned to operate the gray level display system on one of CN Marine's ferries on Northumberland Strait this past winter to monitor ice conditions. Unfortunately, for the research, ice conditions never became severe enough to warrant sending our staff on location to set up and operate the display unit. INSTRUMAR Ltd. conducted more work of a similar type in the Beaufort Sea this ice season with a number of alternate equipment configurations.

Seabed Program

The first phase of the iceberg scouring study, undertaken in the region of the Davis Strait, where Canterra Energy Ltd. drilled the Hekja and Raleigh Wells, was completed. Further cores were needed from the research area to enhance the data base and these were collected by Geomarine Associates (Newfoundland and Labrador) Ltd. during the summer drilling season. In addition, geophysical data collected by Nordco Ltd., again for Canterra Energy Ltd., provided the necessary stratigraphic control. Regional geophysical data were also collected during a cruise of the *CSS Hudson* in Davis Strait and Baffin Bay in which C-CORE participated. The project will be completed by September 1983.

Members of the Seabed Group participated jointly on board the *CSS Hudson* with the Atlantic Geoscience Centre of the Geological Survey of Canada in iceberg scour studies and seabed investigations of areas of interest on the Labrador Shelf. In particular, sites of known iceberg groundings were examined to complete the data base for iceberg scour modelling of real events. In conjunction with this, the group has initiated an extensive research program to delineate iceberg grounding frequencies from wellsite observations. This study includes analysis of grounding velocities and regional theoretical grounding predictions.

Detailed studies on the Hamilton Bank, Labrador Shelf, of particular iceberg scours and further examination of seabed conditions were carried out using the Canadian Armed Forces submersible *SDL-1* on the *HMCS COR-*

MORANT in August. This work formed part of NORPLOY '82, a northern naval deployment in which C-CORE was asked to participate as a scientific team. Initial research of iceberg internal temperature studies was begun and by the end of the year this had become a major research thrust of the group.

The seabed corer underwent major modifications and instrumentation changes this past year based on the results of the first sea trials. Results of more recent sea trials in November 1982, in Placentia Bay, indicate that the seabed corer is ready to be used in areas of interest offshore, such as Hibernia. The design research has not only helped to develop the C-CORE corer but also has brought to light some new ideas in drilling and instrumentation of future coring and *in situ* testing devices.

Research on the hazards of iceberg scour, sediment transport and erosion potential in the Hibernia area of the northeastern Grand Banks, continued as a major program of the Seabed Group in conjunction with scientists at the Atlantic Geoscience Centre. The initial focus of the research has broadened to cover hydrocarbon activity and possible pipeline routes.

Finally, two new projects were initiated at the end of this year. In Hopedale Saddle, on the Labrador Shelf, highly disturbed Quaternary sediments in areas of future drilling are being analysed. Secondly, an initial evaluation of continental slope processes and geological hazards is taking place based on industrial wellsite survey data and other data from the slope areas off the Newfoundland and Labrador Shelf. Both these projects relate to areas of the seabed that are potentially very unstable and the program will provide detailed information on the engineering hazards to be encountered in offshore development.

Ice Properties Program

In 1982-83 the Ice Properties Group developed new techniques to measure the mechanical properties of ice. During two field trips to Tarsiut Island, N.W.T., acoustic techniques and an instrumented auger were employed to define the specific energy, relative hardness and consolidation of block ice in the surrounding rubble field. Logistic support was provided by Gulf Canada Resources Inc. Further work was undertaken off St. John's in the Spring of 1983. The results of these two projects will provide more data for qualifying all types of ice structure interactions.

At Adam's Island, C-CORE collaborated with the National Research Council in its project to observe and measure the behaviour of ice around the island under various weather and sea conditions.

In the vicinity of Pond Inlet, a detailed analysis of ice deformation was conducted. This study defined structural changes occurring in a sheet of first year sea ice during its development and subsequent decay. Analysis of this data will be used to define the theoretical limits of the strength of this type of ice.

Since the temperature of an iceberg determines, to a great extent, the physical and mechanical properties of the ice, a preliminary study was undertaken to predict the range of temperatures one may expect in icebergs along the coasts of Newfoundland and Labrador and to measure the temperature of several bergs to confirm these predictions. The results of this study have been published. In addition to this study, an investigation of the interactions of bergy bits (large pieces of floating glacier ice) and waves, including theoretical modelling and tank tests, was initiated.

A preliminary study for a Canadian Sea Ice Guide was undertaken. Subsequently, funding support for the project was received from the Max Bell Foundation and Canada Oil and Gas Lands Administration (Department of Energy, Mines and Resources). The intent of the project is to extract and compile available ice environment information which is relevant to loads on offshore structures and to the support facilities and activities of offshore operations. The final product will be an environmental index classification system which will provide a definitive information base for the eventual derivation of design standards. This will be in the form of an on-line data base which can be readily updated. The information will also be compiled into an atlas.

Ocean Engineering Information Centre (OEIC)

The OEIC has continued to support the information functions of C-CORE, the Ocean Engineering Group of the Faculty of Engineering and many of the local scientific and engineering community who are involved in the offshore. Nearly half of the OEIC's information work has been to respond to enquiries from government and industry. This year, there has been a significant increase in requests for information on the Canadian offshore from Norway.

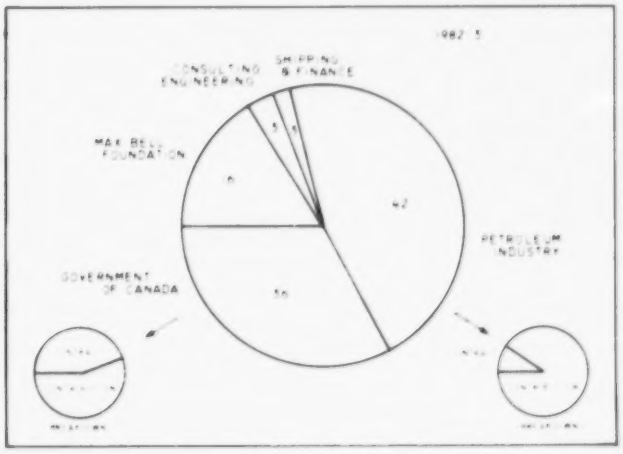
The OEIC also undertook work on behalf of Canada Institute for Scientific and Technical Information (CISTI) at the National Research Council to identify some of the STI (Scientific and Technical Information) services which are required in the St. John's community to support ocean related activities. This information will also assist in planning the library facility for the Arctic Vessel and Marine Research Institute.

Unusually heavy ice conditions near St. John's this past winter, gave C-CORE researchers an excellent opportunity to study icebergs and sea ice close to home. Taken just outside St. John's Harbour, the photo shows Cabot Tower and Signal Hill in the background.

Funding

In spite of the recent economic conditions, the Centre has continued to receive funding for programs from the Associates of C-CORE. Several new Associates have joined the group which now totals thirty-five. Increasingly, contributions are specified for research projects which are of particular interest to the Associate. C-CORE also undertakes contracts with Associates if the work is within the long term research goals and objectives of the Centre. A breakdown of funding received from the Associates is shown in the pie graph below.

The Centre, under the direction of the Finance Committee of the Board, recently contacted many ocean and petroleum related companies in Canada and the United States to promote an awareness of the ongoing research programs at the Centre. Over the next few months further support for the programs will come from companies in areas other than the petroleum sector and thus broaden the funding base of the Centre.



Financial

C-CORE's operating account position for 1982/83 is presented on the accompanying Balance Sheet and Statement of Revenue, Expenditure and Surplus. These have been prepared on an accrual basis. The C-CORE Research Trust which stood at $1,217,900 at the beginning of the year under review, received contributions of $871,000 and interest income of $124,543 for the year. The drawdown of funds from the Research Trust to the operating account of $1,274,530 was authorized to cover the operating expenditures. A further $339,720 was received from project funding, contracts and other sources for the research programs and credited to the operating account. This resulted in a total revenue for the year of $1,614,250. Expenditures for the year were $1,646,884.

In addition to financial contributions, contract revenue and other money, C-CORE received support in kind estimated to be $420,000 in the form of field services and logistic support from government agencies and industries. Accomodation, laboratory facilities, and administrative support services were provided by Memorial University.

For the 1983/84 fiscal year, the Centre has budgeted capital and operating expenditures and income from all sources of $1,832,500.

Board of Governors

The Centre lost a strong and active supporter when Ford Hewlett, a member of the Board and Chairman of the Finance Committee, died in late 1982. His participation in C-CORE affairs will be missed.

In early 1983, Mr. Gordon Harrison resigned from the Board. C-CORE appreciated the direction and challenge he gave to its research teams. Mr. James Stanford of PetroCanada Resources joined the Board. Mr. Harold Lundrigan assumed responsibilities as Chairman of the Finance Committee. The Board recommended a number of new appointments to the President of the University. Mr. Gordon Haight, Vice-President, Esso Resources Canada Ltd.; Mr. Dan Motyka, Vice-President - Frontier, Gulf Canada Resources Inc.; and Mr. Craig Dobbin, Craig Dobbin Ltd. Two new appointments were made to the Committees; Dr. Christopher Barnes, Head of the Department of Earth Sciences joined the Research Program Advisory Committee and Mr. Wayne Thistle, Vice-President (Administration and Finance) Memorial University joined the Finance Committee.

The Board held two meetings during the year to which special guests were invited. The September 1982 meeting was held in Churchill Falls. The informal setting contributed to a stimulating discussion on cold ocean engineering research, and the implications of its longer term directions for the Centre's research programs. The March 1983 meeting in Calgary was joined by special guests from the Petroleum Industry. Presentations of the research programs were made to the Board members, special guests and other representatives of the Petroleum Industry. The goals of the Centre's research programs were reviewed and assessed and the value of a long term research plan was reinforced.

A. A. Bruneau
Chairman

H. L. Snyder
Director

The Research Plan

Introduction

The objectives of the Centre's technical programs are reviewed by the research staff with the Board of Governors and with representatives of the Associates of C-CORE. The review process ensures that the Centre's ongoing research programs continue to address the technical problems faced by many branches of industry and government, in operating year round in a harsh ocean environment.

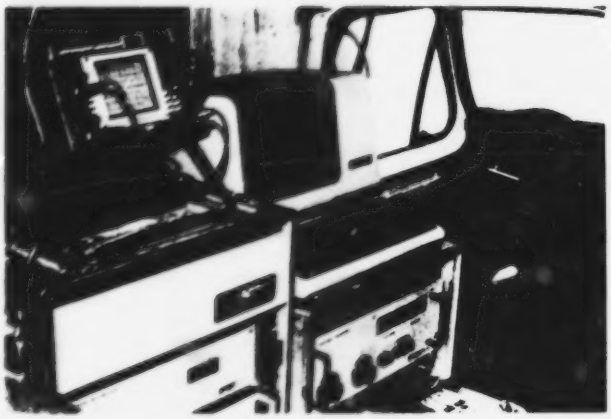
In the following report the research programs of the three groups are outlined and the benefits to be gained from these programs are presented.

Radar and Remote Sensing

Offshore operators need a real time marine environmental information system to provide them with data, quickly and accurately. Such environmental data are required for forecasting weather, monitoring ice and iceberg hazards and predicting critical events in the ocean regime.

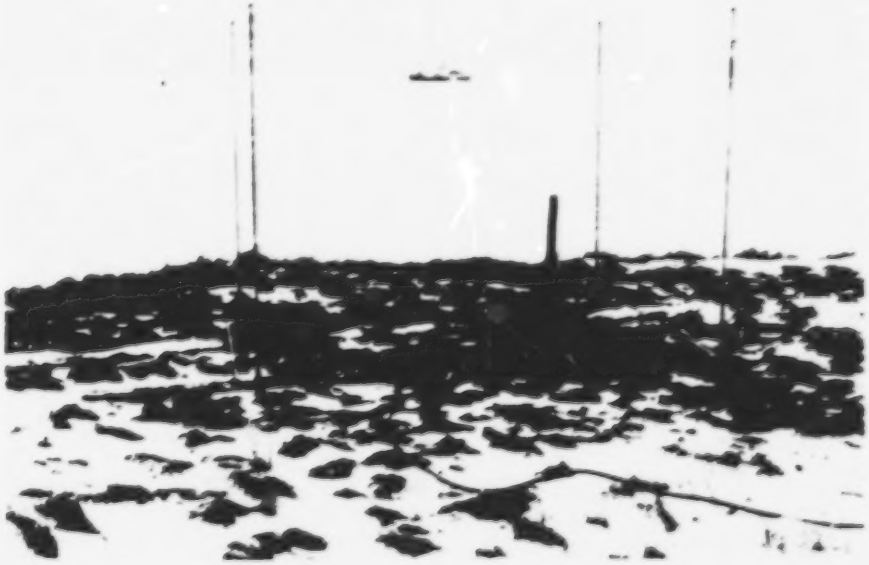
The HF radar remote sensing program has two major objectives: the detection and tracking of sea ice and iceberg hazards, and the measurement and monitoring of ocean conditions. Primarily, the results of this research would be used to support an integrated real time environmental prediction system. As it develops over the next few years, this remote sensing capability will be able to provide ocean current and wave information together with data on ice conditions and iceberg motion. The application of the HF radar remote sensing technique will provide an operational tool and a service to ocean industry and to government.

The Centre is also involved in the application of satellite remote sensing of ice and oceans. The development of the RADARSAT project will provide the ability to monitor ice conditions, unrestricted by cloud cover. The Centre is interested particularly in the satellite imagery and the associated data streams of this system and how this information could be applied, quickly and accurately, to the various problems facing offshore operators from both industry and government.



The transceiver, LSI 11/23 computer and test gear at one CODAR site in a van which acted as the portable housing for this field survey.

The problem now facing operators who wish to use satellite information, is that there is a large volume of data coming in which is of limited value until it is analysed. This analysis may take so long that the information is of little or no use for immediate application. C-CORE recognizes that different groups operating in frontier regions offshore need to have different aspects of this satellite data made available to them quickly and in a form which they can use. Customized "packages" of ocean and ice related data must be developed for individual groups so that the information coming in from the satellites may be used effectively.



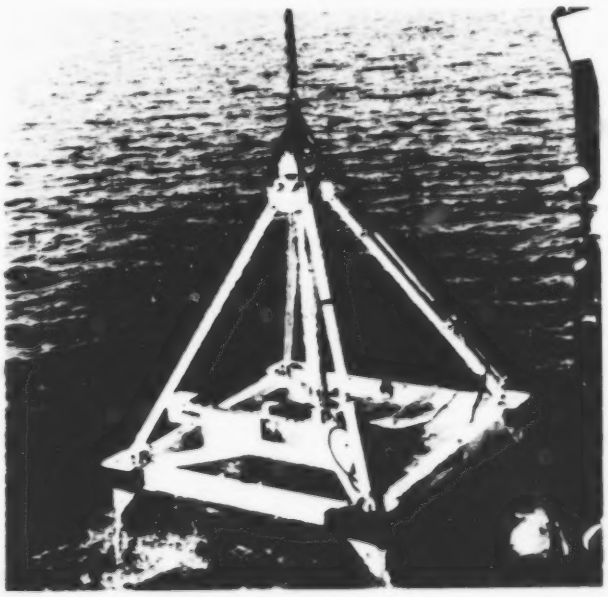
The receive antenna for a CODAR site deployed on the sea bank at Cappahayden, Newfoundland for a surface current measurement trial for the southeast Avalon. Offshore the *CCGS BARTLETT* is attempting to recover a navigation buoy from the pack ice. To our knowledge this is the first time CODAR has been operated over an ice covered range.

The sidescan mosaic (above left) shows the thoroughly disturbed seabed in an area to the north of Hekja 0-71 drilled by Canterra in southern Davis Strait. From the cross-cutting relationships of the curvilinear iceberg scours the sequence of scouring was determined. From this, two of the youngest and one of the oldest scours (a, b and c respectively, above right) were identified. If cores can be retrieved from the troughs of these scours it should be possible, using paleontological and radiometric dating techniques, to find out the time period over which scouring has occurred and also the frequency of scouring, for this area. (Taken from C-CORE Technical Report 83-3).

Seabed Group

The seabed program has been very successful in cooperative ventures with other research laboratories. Our research is presently focussed on tackling the problems associated with the occurrence of icebergs in the Eastern Arctic extending down to the Labrador and Newfoundland offshore. A major program run by the Centre, is to estimate the frequency of iceberg grounding incidents, based on field work and on information which is available from a number of data sources. The major portion of our research on this topic has centred around the information contained in the morphology of the surficial sediments of the continental shelf. We believe this information provides a significant historical record of iceberg groundings for what may be thousands of years. A new research directive is to augment this approach by rationalizing the results with actual observations of iceberg groundings and iceberg drift from available data. This program is being expanded to address the seabed loadings caused by an iceberg in a collision situation and to formulate hazard indicies for the East Coast operating areas. Frequency return rates and seabed loading values now exist but over the next few years, while engineering designs are being formulated, refinement of deviation will be the focus of these studies. The future program also plans to investigate more fully the ambient temperatures of icebergs and material strength of iceberg ice, the geotechnical consequences of seabed loadings from iceberg groundings and the motions of icebergs and growlers driven by stormy seas.

While involved in the initial work on iceberg behaviour, our researchers have become cognizant of the fact that there are other seabed processes which are important for future ocean developments. A knowledge of the degree and type of sediment instability and transport and of foundation erosion will directly influence the ultimate selection of engineering structures or systems. Seabed sampling is costly; there is a need for instrumentation development both for the removal of specimens and for making *in situ* tests of the seabed. To deal with these problems, C-CORE has designed and built a seabed corer which is in its final stages of development. The presence of boulder beds and potential seabed instability due to shallow gas formations are other seabed hazards which must be considered in the selection of sites for seabed installations. Future research programs will tackle these problems.



The seabed coring device being tested in Placentia Bay, Newfoundland.

Future direction for our seabed work will also include an investigation of the continental slope. The initial program will concentrate on sediment types and slope stability, in a specific study site, to evaluate the processes of active sedimentation slumping.

Ice Properties

The Centre's ice research program is directed towards relating the properties and behaviour of ice to engineering problems in the cold ocean environment. The present investigations address the basic topic of the ice strength from a large scale and a microstructural perspective.

On the large scale, techniques are being developed which measure, in the field, the mechanical properties of sea ice in a rapid but precise manner. To complement the research of NRC's Arctic Vessel and Marine Research Institute, the Ice Properties Group is turning its attention to characterizing prototype ice so that it may be modelled accurately in the ice tank. The data collected from icebreakers and stationary structures presently operating in ice environments will be needed to validate model tests.

On the smaller scale, investigations are underway to define how environmental parameters control sea ice strength. Once these are determined, it will be possible to predict sea ice strength from a knowledge of the external conditions under which the ice body developed. To date work has concentrated on first year sea ice; similar methods will be applied to more complex ice types in the future.

Sea Ice Guide

The Canadian Sea Ice Guide program will be completed in March 1985. A technical advisory committee will monitor the project closely and give advice on the design of the information data base so that it will be of value both for the evolution of engineering design and for the functional operations of its potential users. The system will be designed so that the data can be updated continually with new ice environmental information. The Sea Ice Guide will form a major component of a reference base for sea ice and marine information being developed in the Newfoundland community. In the process of completing the project, the identification and definition of critical data gaps in ice environment/engineering information will indicate new areas which the Centre's research programs could investigate.

Two C-CORE researchers at Tarsiut Island, N.W.T., using an instrumented auger to define the specific energy, relative hardness and consolidation of block ice in the surrounding rubble field. Logistic support was provided by Gulf Canada Resources Ltd.

Iceberg Research

Recent work includes the measurement of borehole temperatures of icebergs near St. John's (lower left). These data will provide valuable information on the physical and mechanical properties of iceberg ice near the surface of the berg. In the coming year similar work will be conducted on smaller glacial ice masses, such as bergy bits and growlers, which in conjunction with kinematic studies of small ice masses in ocean waves, will provide a good idea of the damage potential of undetectable ice bodies to marine structures.

The Research Group

Harold Snyder	Director
William Winsor	Assistant Director
Judith Whittick	Administrator, Head, OEIC
Vaughn Barrie	Leader, Seabed Group
Ken Butt*	Leader, Radar Group
Sherilyn Beaton	Projects Controller
Mary Booton	Administration
Denny Christian	Instrumentation
William Collins	Seabed Processes
Deborah Diemand	Iceberg Measurement
Rod Donnelley	Ice Radar Analytic Development
Randy Gillespie	Seabed Processes
Joy Harmon	Ice Forces and Interactions
Ken Hickey	Radar Data Processing
Phil Jeans	Ice Radar Engineering
Ken Klein	Ice Radar Development
Eleanor Nesbitt-Friis	Editor
Bruce Parsons	Ice Forces and Interactions
Chris Pereira	Seabed Geology
Chris Rendell	Statistical Analysis and Programming
Chantal Roche	Radar Data Coordination
Chris Ruck	Ice Environments
Barbara Rodden	Information, Data Bank
Alvin Simms	Statistical Analysis Programming
Ed Stander	Ice Microstructure
Chris Woodworth-Lynas	Iceberg Scour Analysis

*Seconded from INSTRUMAR Limited part-time

Support Staff Group:

Cavell Kavanagh
Rosalie Murphy
Gail Greenslade
Linda Davis
Sheila Bartlett
Norma Matthews

Research Group Members who have left the Centre to take up new positions:

Ernie Reimer
David Bazeley
Gary Gidney
A. Pushpanathan
Eric Woolgar
Randy Raymond

Another 20 individuals joined the research and support groups for part of the year from many sectors of the engineering and scientific community. These included secondments from industry, research terms with academic faculty, and student assistants from engineering and other subject areas.

The C-CORE Fellowships for graduate students in Ocean Engineering awarded last year to Roy Dawe. ("Geotechnical Investigation of Seabed Stability off Canada's East Coast") and to John Murray ("The Effect of Ocean Wave Groups on Floating Structures") was renewed for a second year. Satish Srivastava was supported by the Radar Group.

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
BALANCE SHEET AS AT 31 MARCH 1983

	1983	1982 Restated
Assets		
Research trust (Note 4)	$ 938,913	$1,217,900
Accounts receivable	164,763	161,084
Prepaid expense	—	8,774
	1,103,676	1,387,758
Fixed assets - at cost		
Bartlett Building (Note 3)	1,038,841	1,038,841
Equipment	567,810	486,405
Less: Accumulated depreciation	387,886	274,154
	179,924	212,251
	1,218,765	1,251,092
Total assets	$2,322,441	$2,638,850
Liabilities and Deficit		
Accounts payable and accrued liabilities	$ 61,716	$ 62,944
Interest-free advance from Memorial University of Newfoundland with no specific terms of repayment	287,433	290,993
Total liabilities	349,149	353,937
Equity		
Equity in research trust	938,913	1,217,900
Equity in building	1,038,841	1,038,841
(Deficit) surplus	(4,462)	28,172
Total equity	1,973,292	2,284,913
Total liabilities and equity	$2,322,441	$2,638,850

See accompanying notes.

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
STATEMENT OF REVENUE, EXPENDITURE AND DEFICIT
FOR THE YEAR ENDED 31 MARCH 1983

	1983	1982 Restated
Revenue		
Research trust	$1,274,530	$1,300,000
Research contracts	316,422	242,497
Other	23,298	43,022
Total revenue	$1,614,250	$1,585,519
Expenditure		
Staff salaries	$ 809,285	$ 830,494
Research programs	517,690	462,478
Support services	108,886	114,516
Ocean Engineering Information Centre	83,006	85,102
Fellowships and training	80,395	17,000
Board of Governors	47,622	47,491
Total expenditure	1,646,884	1,557,081
(Deficit) surplus for the year	(32,634)	28,438
(Deficit) surplus - beginning of year	28,172	(266)
(Deficit) surplus - end of year	$ (4,462)	$ 28,172

See accompanying notes

Signed on behalf of Memorial University of Newfoundland

Chairman of the Board of Governors

Comptroller of Memorial University of Newfoundland

CENTRE FOR COLD OCEAN RESOURCES ENGINEERING
NOTES TO FINANCIAL STATEMENTS
FOR THE YEAR ENDED 31 MARCH 1983

1. Accounting Policies

(a) The Research Trust is shown on a cash basis.

(b) Depreciation is calculated on a straight line basis as follows:

Equipment	5 years
Tools and marine equipment	2 years
Computer software and other equipment	1 year

No depreciation is recorded on the Bartlett Building.

2. Relation to Memorial University of Newfoundland

The Centre for Cold Ocean Resources Engineering (C-CORE) is a self-reliant organization of Memorial University, which is owner of C-CORE's building and equipment and beneficiary of its assets and liabilities. In the event that C-CORE is terminated, facilities and equipment provided or acquired for C-CORE shall remain the absolute property of the University.

As such, these financial statement figures represent a segment of the activities of Memorial University of Newfoundland and are included in the audited financial statements of the University for the year ended 31 March 1983.

3. Bartlett Building

In order to properly reflect the entire operations of C-CORE as a separate entity, the Bartlett Building, which is owned by Memorial University of Newfoundland but of which C-CORE has exclusive use, has been included in the financial statements for 1983 and 1982 at a cost of $1,038,841.

4. Funds in Research Trust

All the incoming funds which are designated as contributions to C-CORE's research programs are deposited for credit to the C-CORE Research Trust. The Comptroller of Memorial University of Newfoundland administers the C-CORE Research Trust on behalf of the Trustee, the Board of Regents of Memorial University.

Cash transactions in the Research Trust during the year were as follows:

Balance in bank, 1 April 1982	$1,217,900
Receipts:	
Industry	371,000
Max Bell Foundation	250,000
Government of Canada	250,000
Investment income	124,543
	995,543
Less: Transferred to the Centre's Operations	1,274,530
Net contribution during the year	(278,987)
Balance in bank, 31 March 1983	$ 938,913

5. Support-in-kind

Management has estimated the cost of various services provided without charge by Memorial University of Newfoundland, the Province of Newfoundland and other agencies at $420,000 for the year ended 31 March 1983 ($455,000 — 1982).

6. Restatement of comparative (1982) financial statements

The balance sheet as at 31 March 1982, and the statement of revenue, expenditure and surplus for the year then ended, which are presented for comparative purposes, have been restated to reflect the correction of prior years' accounting errors. As a result of the correction of these errors, the following financial statement amounts have been restated:

	As previously reported	1982 Restated
Fixed assets:		
Equipment	$468,820	$486,405
Accumulated depreciation	270,637	274,154
Interest-free advance from Memorial University of Newfoundland	279,858	290,993
Surplus - end of year	25,239	28,172
Surplus (deficit) - beginning of year	19,643	(266)
Research programs (expenditure)	485,320	462,478

The balance sheet as at 31 March 1983 and the statement of revenue, expenditure and deficit for the year then ended reflect fairly the results of the above corrections.

DEPARTMENT OF THE AUDITOR GENERAL
ST. JOHN'S, NEWFOUNDLAND

AUDITOR'S REPORT

The Board of Regents
Memorial University of Newfoundland
St. John's, Newfoundland

I have examined the balance sheet of the Centre for Cold Ocean Resources Engineering as at 31 March 1983 and the statement of revenue, expenditure and deficit for the year then ended. My examination was made in accordance with generally accepted auditing standards and accordingly included such tests and other procedures as I considered necessary in the circumstances.

In my opinion, these financial statements present fairly the financial position of the Centre as at 31 March 1983 and the results of its operations for the year then ended in accordance with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

J. F. McGrath, C.A.

J. F. McGrath, C.A.
Auditor General

St. John's, Newfoundland
23 June 1983

Board of Governors

Dr. A. A. Bruneau, Chairman
President, Bruneau Resources Management Ltd.

Professor C. D. diCenzo
Dean of Engineering & Applied Science
Memorial University of Newfoundland
(retired August 1982)

Mr. H. M. Clarke*
Deputy Minister
Department of Development
Government of Newfoundland & Labrador

Dr. A. E. Collin**
Associate Deputy Minister
Energy, Mines and Resources Canada

Mr. G. N. Ewing**
Assistant Deputy Minister
Ocean Science & Surveys
Fisheries & Oceans Canada

Mr. G. R. Harrison
President, Canadian Marine Drilling Ltd.
(retired February 1983)

Mr. E. F. Hewlett
Chief Executive
Hewlett Group of Companies
(Deceased October 1982)

Mr. H. Lundrigan*
Senior Vice-President
Lundrigan's Limited

Mr. W. Mason
President and General Manager
Mobil Oil Canada Ltd.
(retired March 1983)

Dr. G. R. Peters**
Dean of Engineering & Applied Science
Memorial University of Newfoundland

Dr. R. Pottie*
Atlantic Regional Director
National Research Council of Canada

Mr. H. L. Snyder**
Director
Centre for Cold Ocean Resources Engineering

Mr. J. Stanford
President, Petro Canada Resources Inc.

Ms. J. A. Whittick, Secretary
Administrator
Centre for Cold Ocean Resources Engineering

Ms. S. J. Beaton, Assistant Secretary
Projects Controller
Centre for Cold Ocean Resources Engineering

*Members of the Finance Committee

**Members of the Research Program Advisory Committee

ASSOCIATES of C-CORE

Arctec Canada Limited
Bechtel Canada Limited
BP Exploration Canada Limited
Bow Valley Industries Ltd.
Brown & Root Ltd.
CN Marine
Canadian Superior Oil Ltd.
CanOcean Resources Ltd.
Canterra Energy Ltd.
Det norske Veritas
Dobrocky Seatech (Nfld.) Ltd.
Dome Petroleum Limited
Esso Resources Canada Limited
Fenco Newfoundland Limited
Fisheries & Oceans Canada
Golder Associates
Gulf Canada Resources Inc.
Huntec ('70) Ltd.
INSTRUMAR Limited
Melville Shipping Ltd.
National Research Council Canada
NORCEN Energy Resources Limited
NORDCO Limited
O. D. C. Scientific Limited
PanCanadian Petroleum Limited
Petro-Canada
Polar Gas Project
Remotec Applications Inc.
Royal Bank of Canada
ShawMont Newfoundland Limited
Shell Canada Resources Limited
Texaco Canada Resources Ltd.
Transport Canada
Viatec Resource Systems Inc.
Westinghouse Canada Inc.

After-Tax Cost of C-CORE Research Support

C-CORE as a 'Research Institute' qualifies under the provisions of the Income Tax Act which allows payments to an approved institute to be related to the taxpayers class of business. In addition, the act allows for a research allowance for certain R & D expenditures to all corporations doing business in Canada.

Thus R & D expenditures contributed to C-CORE could qualify for the investment tax credit. A corporation able to take full advantage of the tax savings, sees a net cost of its investment in C-CORE as approximately 15% - 17% of its contribution.

Reports and Publications for 1982

82 - 1 Josenhans, H. W. and Barrie, J. V. "Preliminary Results of Submersible Observations on the Labrador Shelf". Geological Survey of Canada Current Research, Part B, Paper 82-18, 1982, pp. 269-276.

82 - 2 Barrie, J. V., Pereira, C. P. G. and Woodworth-Lynas, C. M. T. "Data Report on the Hekja Wellsite Marine Survey, *CSS HUDSON* Cruise 81-045". Data Report, May 1982, 50 p.

82 - 3 Diemand, D., Reimer, E. M. and Barrie, J. V. "Ocean Drifter Studies of Surface Currents along the coasts of Newfoundland and Labrador and in the Beaufort Sea". Technical Report, May 1982, 35 p.

82 - 4 Barrie, J. V., Lewis, C. F. M., Fader, G. B., King, L. H. and Amos, C. L. "Seabed Processes on the Northeastern Grand Banks; Modern Reworking of Relict Sediments". Abstract accepted for the Eleventh International Congress on Sedimentology, McMaster University, Hamilton, Ontario, August 22-27, 1982.

82 - 5 Woolgar, E. G. and Reimer, E. M., "Comments on a Technique to Measure Mixing Energy Available for Oilspill Dispersion". In Proceedings of the 5th Arctic Marine Oilspill Program Technical Seminar, Edmonton, Alberta, June 15- 17, 1982, pp. 25-36.

82 - 6 Josenhans, H. W. and Barrie, J. V. "The Effect of Icebergs on the Labrador Shelf as seen by Submersible *PISCES IV*". Geological Survey of Canada Open File 843, 3/4 inch colour videotape, 18 minutes. Available for viewing at the Dartmouth Open File only. Copies may be obtained at the user's expense from ABS Productions Limited, 196 Joseph Zatman Drive, Dartmouth, Nova Scotia, B3B 1N4, 1982.

82 - 7 Barrie, J. V., Lynas, C. M. T. and Gidney, G. "Iceberg Grounding Review from Wellsite Observations". Geological Survey of Canada Open File 880, Contract Report prepared for Geological Survey of Canada. Available for viewing at all Geological Survey Libraries. Copies may be obtained at user's expense from Precision Microfilming Services Limited, 6061 Young Street, Halifax, Nova Scotia, B3K 2Y3, 1981, 33 p.

82 - 8 "An Assessment of Impulse Radar as an Iceberg Draft Measurement Tool". Contract Report prepared for C-CORE by Remotec Applications Inc. Available from C-CORE, November 1982, 47 p.

82 - 9 Walsh, J. "A General Theory of the Interaction of Electromagnetic Waves with Isotropic, Horizontally Layered Media, and Applications to Propagation over Sea Ice." Technical Report, August 1982, 54 p.

'Technical Reports', 'Data Reports', 'Cruise Reports', 'Conference Proceedings' and Information Publications are normally available from C-CORE. The availability of 'Contract Reports' is noted individually. Preprints of papers presented by C-CORE members to external meetings or submitted to other publications are available from C-CORE, unless timely external publication is expected.

Information Publications for 1982 - 1983

82-A "C-CORE News, Vol. 7, No. 1", February 1982, 8 p.

82-B Bazeley, D. P. "C-CORE, Ice and Engineering Research." Dialogue for Engineers (APEN) St. John's, May 15, 1982, pp. 1-3.

82-C "C-CORE News, Vol. 7, No. 2", June 1982, 8 p.

82-D "C-CORE Annual Report 1981-82", August 1982, 16 p.

82-E "C-CORE News, Vol. 7, No. 3", November 1982, 8 p.

83-A "C-CORE News, Vol. 8, No. 1", March 1983, 8 p.

83-B "C-CORE News, Vol. 8, No. 2", July 1983, 8 p.

83-C "C-CORE Annual Report 1982-83", 1983, 17 p.

83-D Collins, W.T. "Iceberg and Other Seabed Hazards Related to the Production of Oil and Gas off the East Coast of Canada". Newfoundland Journal of Geological Education, in press.

83-E "C-CORE News, Vol. 8, No. 3", November 1983, 8 p.

Reports and Publications for 1983

83 - 1 Pereira, C. P. G. "Iceberg Scouring off the Southeast Baffin Island Continental Shelf, Eastern Canada — Abstract Results". Iceberg Research, No. 3, February 1983, 15 p.

83 - 2 Woodworth-Lynas, C. M. T. "A Possible Submarine Mud Volcano from the Southeast Baffin Island Shelf". Technical Report, March 1983, 38 p.

83 - 3 Woodworth-Lynas, C. M. T. "The Relative Age of Ice Scours Using Cross-Cutting Relationships". Technical Report, March 1983, 54 p.

83 - 4 Collins, W. T. and Diemand, D. "Norploy Cruise Report". Cruise Report, April 1983, 31 p.

83 - 5 Diemand, D. "Iceberg Temperatures — Preliminary Report". Technical Report, April 1983, 31 p.

83 - 6 Barrie, J. V. "Sedimentary Processes and the Preservation of Iceberg Scours on the Eastern Canadian Continental Shelf". In Proceedings of the 7th International Conference on Port and Ocean Engineering under Arctic Conditions (POAC 83) Helsinki, Finland, April 5-9, 1983, Vol III.

83 - 7 Pereira, C. P. G. "Marine Geology off Southeast Baffin Island — Results from a 1981 and 1982 Survey". Bulletin, American Association of Petroleum Geology, 1983, V. 67 (3) p. 531 (Abstract).

83 - 8 Butt, K. A., Jeans, P. K. and Raymond, R. C. "HF Radar Technology Transfer Project — Acquisition Phase March 1982". Technical Report, June 1983, 107 p.

83 - 9 Butt, K. A. and Hickey, K. J. "HF Radar Technology Transfer Project — Single Site Data Analysis". Data Report, in press.

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